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THE FRANKLIN INSTITUTE.

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Alumino-Thermics, or the Production of High Temperatures by Burning Aluminum.

BY E. STÜTZ.

I sincerely thank the officers of the Franklin Institute for the kind reception and for the opportunity courteously given me of explaining to you some of the results of Dr. Hans Goldschmidt's remarkable discoveries in the creation of high temperatures by means of aluminum.

I think I may say that Dr. Goldschmidt would have greatly liked to have been able to address the members of this world-famous Institute, the more so as two facts connect this city with the subject of my lecture. The one that your distinguished secretary, Dr. Wahl, was among the first scientists to demonstrate the heat-producing qualities of aluminum; the other, that on this continent it was in your city where Dr. Goldschmidt's process was successfully ap-

plied some time before its importance was more generally recognized.

I began by stating that it was aluminum that produced the high temperatures, some of the effects of which will be demonstrated to you presently. But not aluminum alone; it required to be brought into intimate contact with the commonest of the elements on this planet, oxygen. By producing in a suitable manner the combination of these two, Dr. Goldschmidt obtained a temperature equal to that of the electric arc light. That is the starting point of the new science, christened in this country—I believe by Dr. Roeber—"alumino-thermics." The suitable manner of combining the two elements consists in *not* taking the atmospheric oxygen, but the solid one contained in the oxides and mixing these with finely granulated or pulverized aluminum. The resulting mixtures are the heat producers and are now known by the name of "thermit."

The first important discovery in observing the properties of these mixtures was that, when ignited in one spot, the combustion continued throughout the whole mass without any supply of heat from outside. The thermit is placed in crucibles which are not in contact with any external source of heat, and the combustion once started, embraces the whole mass in a very short time. This is the essence of alumino-thermics.

The thermit mostly used is iron thermit, in appearance a grayish-black powder. This is ignited by applying a storm match to a small pinch of ignition powder placed well in the middle of the surface of the thermit. The reaction is started at once, proceeds quickly and steadily, and is finished —whatever the quantity used—in less than a minute.

EXPERIMENT I. IGNITING THERMIT.

In the crucible after the reaction there are two layers. The bottom one is pure metal of equal weight to, but occupying only one-third of the space of the top layer, which is now oxide of aluminum, so-called corundum.

These two layers whilst still liquid are poured rapidly over the lip of the crucible. It is not difficult to distinguish

between the slag which flows first and the brightly glittering overheated metal.

EXPERIMENT II. POURING THERMIT.

I think the metal looks hot enough, but to demonstrate better than by mere figures what this heat means, I will now burn a hole through a 1-inch wrought-iron plate. The heat is computed to be about 5,400° F. (3,000° C.).

You will notice that in this case the crucible is tapped from the bottom so as to allow the pure iron to run out first. The hole is perfectly smooth-edged; the heat is so concentrated that the plate is still cold after the reaction.

EXPERIMENT III. BURNING HOLE THROUGH PLATE.

To arrive at such efficiency has required patient study and assiduous work. Each of the various thermit mixtures, although made according to simple chemical rules, required studying out by itself. The formulas for gunpowder or dynamite sound fairly simple, but it requires more than a mere mixture of the ingredients to obtain any effect sufficient for industrial requirements. Not as if thermit were an explosive—you can throw it into the kitchen fire and it won't burn.

In the following I am going to illustrate by practical demonstration a *few* of the applications of the thermit process; to give an account of the entire field of its utility would go beyond the scope of a single lecture.

The applications may be roughly divided into two main divisions, the one concerning the metallurgist, the other the engineer. The latter application may be summarized in the word "welding."

Among the *pure metals* produced by the alumino-genetic reaction, I may mention in the first instance chromium free of carbon, as having already found a market in this country. It is used in the manufacture of particular qualities of chromium steel, with a limited percentage of carbon. For instance, it is considerably used for self-hardening tool steel.

Pure manganese also produced by this process finds employment in copper and nickel manufacture and, furthermore,

in the production of particular sorts of manganese steel of great strength and great elasticity.

There are a number of other rare metals important to the maker of high-grade steel, and to the metallurgist, produced by this process free from carbon, with an enumeration of which I need not trouble you. I shall just show you the nickel thermit reaction.

Although the demonstration is only on a very small scale, it will prove that the process is an extremely simple and expeditious one. In actual manufacturing, several hundred weight are produced in one reaction. At the end of the lecture the mass will have cooled sufficiently to enable me to show the regulus of pure nickel. The slag covering this regulus, particularly in making chromium, is utilized as an artificial emery on account of its great hardness. It has been given the name of corubin. It has also considerable refractory properties which have been utilized in various ways.

EXPERIMENT IV.

The part of the process which has received the widest attention and practical application is the Thermit Welding Process.

Considering the innumerable details connected with the application of so new and practically unknown a force, it is not surprising that only since about a year ago the process has been introduced on a large and commercial scale.

The most important of these welding processes is the one by which a continuous rail—a necessity of modern trolley road construction—is simply, cheaply and effectively obtained. Engineers in this country, in which over 25,000 miles of single track are in existence, are watching the good results obtained in Europe with this system. European authorities recognize its advantages over all its competitors, about 20,000 joints having been welded by this process since about a year ago in forty cities of the Old World.

I may be permitted to explain that, with rails embedded in the streets, exposing only a small surface to the direct influence of change in temperature, the contraction and

expansion are counterbalanced by the friction against the pavement.

The city of Leeds, in England, after careful investigation by a committee of experts, is using this process over the whole of its tracks, and an American expert, who had occasion to see it employed there, on his own initiative, recommended it for a very important contract at Singapore, where, in consequence, it is being used over a track of 27 miles.

The marked advantage enjoyed by this system is the absence of any bulky equipment; a crucible, a mold box and, in some instances where a complete butt-weld of the head of the rail is desired, a rail-clamp is all that is required. All these materials, including the necessary quantity of thermit, can easily be moved on a hand-truck. Each weld, according to section, requires from 15 to 20 pounds of thermit, and the metal welded around the joint will only weigh, therefore, from 7 to 10 pounds.

Even where a rail-clamp is used, the time employed is less than that necessary for fixing fish-plates and copper-bonds.

The mold is made according to a model designed specially for each section. Its two parts, one on each side, firmly enclose and exactly fit the rail. They are made on a large scale by manufacturers of refractory earthenware, or, according to the requirements of the trolley lines, in the repair shops, by tamping an ordinary mixture of china clay and sand into a sheet-iron case placed over the model, which has afterwards to be dried. The cost is only a few cents.

The thermit iron running out of the crucible flows round the web and foot of the rail, and, melting them, forms one mass with them. The liquid slag, which follows the metal, is diverted to the top of the rail and brings the latter to welding heat. The whole section is thus heated equally and the rail ends will not buckle.

The weld can be made with or without rail-clamps. By using the rail-clamps, a perfect butt-weld, without even the smallest slit, is obtained; the slight and very short upset can be easily removed. The rigidity of the joint is particularly great. Under hydraulic pressure the break occurs

outside the welded zone, as with the iron shoe welded on to the section, the joint is really stronger than the rail.

The use of the rail-clamps is, however, by no means obligatory. Without them the work is still further simplified, as the time necessary for adjusting the heavy clamps and for chiseling off the upset is saved. By practical experience, it has been found that the weld without clamps is quite sufficient. Of late the clamps are being used less and less, their use being based chiefly on theoretical considerations. Even a butt-weld can be obtained without clamps, particularly with rails already embedded. At Barmen, Germany, such work was done very successfully about a year and a half ago. The old fish-plates were taken off, the ends of the rails were raised slightly by means of a crowbar and a shim firmly wedged in between; in this case the shim is welded into the head of the rail.

Without clamps a joint takes three-quarters of an hour for one man; trained squads of four men, including foreman, did not use nearly so much time. At $1.50 per day, the wages item of cost is 10 cents per joint. The use of the clamp doubles this amount. All other labor connected with welding remains the same whether clamps are used or not.

The mold, which must be dry and porous, is screwed on to the rail and the rims touching the rail are carefully smeared with clay. Before doing so, however, the rail ends are cleaned of dirt and rust with a wire brush and slightly warmed; a sand-blast is superfluous.

In case the tops of the rails are to be butt-welded, the section has to be filed.

This is all that is required in the way of preparatory work. A true alignment of the rail is, of course, an indispensable precaution. The rails require no bolt holes, as no provisional fish-plates are necessary.

You will recognize that none of this work demands special training, and that, as in Europe, the trolley companies' men in this country will be easily able to do it. A certain amount of supervision is a matter of course.

The welding is done automatically and does not require the trained eye of an expert welder.

In case of wet weather, the protection of a few planks is desirable to prevent the mold and thermit getting wet.

The only remaining appliance necessary for thermit welding is the crucible. This consists of a sheet iron mantle lined with magnesia. It is of simple construction, the lining being introduced by tamping it round a cone which is suspended in the middle of the mantle. The bottom is formed by a hard magnesia stone provided with an exchangeable outlet, which will stand nine to ten runs. Crucibles will stand about twenty-five reactions, and the wear and tear will, therefore, amount to only a few cents per joint. The thermit is supplied in small bags containing the exact weight which is needed to effect the weld. These are called welding portions and are sold as such to the trolley companies. The companies who make their own crucibles and molds, will, therefore, have to pay freight only on the welding portions, which is about one-tenth of that on fish-plates and bolts.

The works of Th. Goldschmidt, at Essen-Ruhr, Germany, who control the thermit patents, have a plant to supply over 500 welding portions daily.

I shall now show you how a rail is welded.

EXPERIMENT V. RAIL WELDING.

The strength of the weld is about 80 per cent. of the strength of the original material. The shoe welded onto the foot of the rail not only makes up for the remaining 20 per cent., but materially strengthens the rail at the joint. The head does not get softer, although it is brought to welding heat; the reason being that the operation takes place without the air having access to it. Test rods cut out of rails brought to welding heat with thermit, prove that tensile strength and elasticity have not suffered; a fact which is confirmed by three years' practical experience on the road.

Mr. Cole, the engineer in charge of the construction of the Singapore tramways, who, as I mentioned, is welding all his joints by the thermit process, writes as follows under date of October 10, 1903:

"We have not had one pull-apart, a thing that would occur very quickly if the weld was not all that was required, for we have large sections exposed to the weather for days *without being covered up*, and the contractive force of the changes of temperature would quickly pull the joints apart if they were not well done.

"The joints are nearly all done in the heat of the day, when the metal is expanded to its maximum limit. We have a difference of over 60° between night and day."

The strength of the thermit joint was tested under hydraulic pressure by Mr. F. S. McGregor, Permanent Way Engineer, Leeds City Tramways, and the results were published in the *Street Railway Journal* of November 13th last.

The so-called third rail is also welded by these means. The skin resistance of copper bonds increases with time, and frequent repairs are necessitated thereby. Welding obviates these repairs. It can be done in two ways. The first is identical with the one described before (but without the use of clamps), and is now in operation on 20 miles of the Metropolitan Underground Road, at Paris, France, where a short track gave satisfaction after a year's trial. The second consists in welding a small bridge of thermit iron between the feet on one side of the rail. Both are in use on a large scale; on the suburban road from Berlin to Grosslichterfelde, the Union Electricitæts Gesellschaft, of Berlin, has welded 13½ miles of track. The rails on this track are exposed, three lengths are welded to one of 45 yards, which is connected to the next by a flexible bond. The other side of the joint, where there is no thermit-welded bridge, is mechanically strengthened by an ordinary light fish-plate. Just as well as 45 yards, much greater lengths might be welded. In this case the crucible is superfluous. The welding portion of about 3 pounds only is placed directly into the upper part of the mold, which is prolonged by a piece of gas pipe.

EXPERIMENT VI. WELDING THIRD RAIL.

It takes less time, as you see, to perform the experiment than to describe it.

The question of the continuous rail with exposed T-rails on railroads is not solved at present for want of sufficient tests. Of course, welding is the only means by which continuous rail properly speaking can be obtained with exposed rails. That it is practicable within certain limits and that it is desirable to have greater lengths of exposed track welded together, is admitted by permanent way engineers. The question is being investigated at present, but some time must elapse before a definite opinion can be arrived at. In any case exposed rails can undoubtedly be welded without any risk in tunnels and subways where differences of temperature are very slight and contraction and expansion therefore only minimal.

Steel girders for construction work can, of course, be welded in just the same way as rails. For really solid jointing equal to the strength of the girder itself, welding is necessarily cheaper than riveting. Some work of this kind has already been done in Germany, but in Europe there are none of the wonderful steel girder constructions which so greatly impress the European on his arrival in this country. There will be a wide field for this work in the United States as soon as the preparatory experiments and calculations have been made and officially sanctioned. After the experiment you have seen here, you will acknowledge the immense saving of time in using the welding process as compared to riveting.

This brings me to the next important application, or rather class of applications, the repair of solid iron and steel objects, a subject full of interest to by far the most numerous, although not the largest consumers of thermit.

The result of the reaction in the crucible is, as you know, a liquid iron, which sinks to the bottom, and an alumina slag that swims on the top.

Whoever has a supply of thermit and ignition powder has a supply of liquid mild steel, which on account of its low contents of carbon, 0·1 per cent., is very malleable and ductile. A man going to the North Pole, if he has a crucible, thermit, ignition powder and a match, can make steel right there.

We need not, however, go to the arctic regions to find useful employment for thermit steel. Whoever has a foundry can correct faulty castings, machinery shops can mend broken or worn-out parts, and last, but not least, marine engineering works can repair large steel castings, such as crank shafts, and particularly broken stern posts.

Wherever the distance from a construction shop is a matter of consideration, and in all outlying districts this thermit is of particular value. Within the last few months regular ton orders have been received from South Africa, where damaged machinery of all kinds has been repaired by it in the mining districts. In many cases cast iron has been welded, the liquid thermit steel being assimilated to the nature of cast iron by an addition of about 1 per cent. silicon in the form of powdered ferro-silicon with 12 to 14 per cent. silicon. This is thrown into the crucible as soon as the reaction is finished and a little time allowed before tapping.

Certain rules have to be observed in all repair work. First and foremost, the slag should not be allowed to get mixed up in the plastic iron. An appropriate position of the runner and a little experience in the construction of the most effective shape of molds will prevent this. The molds must be made so as to allow the liquid iron which runs out of the crucible to flow freely round the flaw or fracture, and to rise in the rising pipe. The latter must be large enough to hold sufficient metal, that the walls of the flaw, etc., are fused. The weld can either be effected by running the thermit iron round the ends of the piece in the shape of a ring, or by both running it between and round at the same time. The size of molds and quality of thermit necessary for welding shafts up to 300 millimeter diameter have been tabulated. A 12-inch diameter takes 190 pounds of thermit, giving 95 pounds of mild steel. These sketches will show some of the various shapes of molds.

The quality of the thermit steel may be adapted to various requirements by mixing small clean iron punchings into the thermit powder. For 10 pounds or more an admixture of 5 to 8 per cent., and for over 50 pounds up to 15 per cent.

of punchings will not make the overheated steel lose the property of melting and fusing with the metal it comes in contact with. This addition will, of course, raise the carbon percentage, a result likewise obtainable by an addition of ferro-silicon. An addition of ½ per cent. of pure manganese free from carbon will also be found useful in many cases.

Steel can be welded on to wrought iron or cast iron, and *vice versa*.

It would be utterly impossible to give advice about the practicability of all or every sort of repairs that it might be desirable to make. The number is legion. All that we can do is to lay down general rules and supply the thermit.

The most startling, and at the same time the most effective, work done in the way of repairs by thermit is in connection with marine engineering. To weld broken stern posts of big transatlantic liners, or crank shafts, or similar pieces, crucibles of 6 feet in height, with a capacity of seven hundred weight, have been constructed. The reaction in these hardly takes longer than in a small crucible. The enormous advantage offered to steamship owners by such repairs will be apparent when it is remembered that a broken stern post would otherwise have to be replaced by a new one. Besides this expense the one incurred through loss of time, the steamer being laid up in dry dock for weeks and weeks, in order to have the new part fitted in, is very heavy indeed.

EXPERIMENT VII. WELDING THERMIT IRON ON STEEL PLATE.

I now come to an application of thermit which differs materially from those I thus far had the privilege of demonstrating to you. That is welding wrought-iron pipes.

Of course, the heat of the iron, if directly applied, would destroy the thin walls of the pipe. Here, then, the corundum slag created on the top of the mass in the crucible comes into play. On being poured it has the properties of adhering instantaneously in a thin layer to any object that it comes in contact with, and of being impervious to liquid thermit iron.

The *modus operandi* is, therefore, changed in some essen-

tial particulars. The reaction takes place in a crucible with a solid bottom, a small quantity of thermit only is ignited at first, and to this more is added as the mass subsides, and finally the contents are poured over the lip of the crucible in order to direct the slag, and not the iron, upon the thin walls of the pipe.

To butt-weld the pipes the ends must be made to fit accurately upon each other, and must be made bright with a file or emery paper. The two pipes are then firmly pressed together by the clamping apparatus, and the sheet-iron mold, well surrounded with moist sand, is attached. Welding temperature will be reached within a minute or two after pouring. The clamps then want tightening; one turn of the screw, and the weld is completed. The mold box is removed almost at once, and can be used several times. The surrounding mass, containing the iron between the layers of slag, like the yolk in the white of an egg, is easily removed with a hammer. Such welds will stand pressure of hundreds of atmospheres, as a matter of fact, as much as the pipe itself. About 30,000 to 40,000 pipe joints have been welded by this method, the advantages of which are shortly, that the operation can take place anywhere *in situ*, and that it is cheaper than a solid flanged joint. The dimensions of the mold have been carefully worked out and tabulated for every size of wrought-iron pipe up to 6 inches diameter. Any workman will be able to make such welds after very short practice, by carefully observing the few rules and directions printed in the pamphlets.

EXPERIMENT VIII. PIPE WELDING.

The numerous other applications of thermit for welding it would take too long to discuss in detail now. But apart from welding there is one large field for which aluminothermics may be of enormous importance. I am referring to foundry practice.

Professor Matthesius, one of Dr. Goldschmidt's associates, has especially devoted himself to studies concerning the improvement of iron and steel castings. These are obtained by introducing the thermit below the surface of the

bath, and so producing a high temperature in one place. A box containing the thermit is fastened to an iron rod and held down on the bottom of the ladle.

For cast iron, and in some cases for steel, a special thermit is used, which gives off an alloy of iron with titanium, so that the titanium enters the liquid metal. The reaction takes place all through the contents of the ladle and thoroughly stirs them up in the space of a minute or two. Gases or particles of slag are driven upwards, so that the fluidity of the iron is increased. An increase of the temperature does not in reality take place, as the proportion of added thermit is only $\frac{1}{4}$ to $\frac{1}{16}$ per cent. of the total contents of the ladle. The effect of the titanium is to bind small quantities of nitrogen, to increase the fluidity of the cast iron and to produce a finer grain.

Another application of the so-called "box reaction" is important for steel castings, and especially for casting large steel ingots, to prevent the familiar phenomenon of piping. In the heads of such blocks hollow spaces are found which mostly cause 30 to 40 per cent. of loss.

The thermit process as used for this purpose consists in introducing a box of so-called anti-piping thermit into a block with the aid of an iron rod, in exactly the same way as described before. According to the size of the block the box is suspended about 3 feet. The reaction is completed in this case in a few seconds. The box is introduced, of course, only after the piping has been formed. The head layer, which has already become solid, is broken through for this purpose. Immediately after the reaction is completed, steel, which is held in readiness for this purpose, is poured into the open hole. Only about 10 pounds of thermit are required for blocks of 10 to 20 tons weight. After the treatment relatively very small flaws were found and only in the upper part of the block, so that the loss is only a very few per cent.

The method has also been applied for very large steel castings to revive steel which has become plastic in the runners. In these the anti-piping thermit is placed at the bottom of some risers, in an annular box with concentric

walls containing about 2½ pounds of thermit. There is in this case no need to thrust the box in by means of an iron rod. The piping will not protrude into the piece, but will be kept right at the head of the riser.

The difficult operation of casting long stern posts of vessels can be facilitated by inserting in several places boxes of this thermit. On account of the long way the steel has to travel, it has a tendency to grow plastic, but coming into contact with thermit, its temperature and thereby its fluidity are revived.

Before concluding I will show you a few lantern slide pictures from photographs of actual work done in all parts of the Old World and then the welds will be opened out for your inspection.

FIRST IRON CASTING IN THE UNITED STATES.

What is believed to be the first iron casting made in the territory now included in the United States, is preserved in Lynn, Mass. Its history is well authenticated. It is a cooking pot, weighing a little over 2 pounds. It was made about 1642, near Lynn, where a small blast furnace was built in that year. This furnace used charcoal for fuel, with bog ore found in the meadows along the Saugus river, and oyster shells as flux. The furnace was operated until 1688, with some intermissions.—*Engineering and Mining Journal.*

PROGRESSIVE TOWN IN NORTHERN CHINA.

It is not to Northern China that one would usually look for an example of electrical progress, but there is at least one place on the Eastern shore of the Liaotung Peninsula which might well set an example to many of the Western towns. We refer to the city of Dalny, which lies near Port Arthur in that portion of the Chinese Empire which was leased to Russia in 1898. Electrically, Dalny is up-to-date. The central station, which is considered the finest electric plant in Asia east of Singapore, was finished over a year ago. It is equipped with three of Ganz & Co.'s generators, with a total of 1,000 horsepower, and has a reserve space for additional machines to double its present capacity when required. Dalny, besides other things, is an important seaport, and has a drydock 380 feet long, 50 feet wide and 18 feet deep, which is equipped throughout with electric pumps. A larger drydock is building, at which electricity will also be adopted. In connection with the drydock are the harbor and repair shops, with foundry, smithy, machine and fitting shop, boiler shop, etc. All these shops are electrically driven and lighted throughout. Dalny also boasts an excellent telephone service, and altogether it may fairly claim to be one of the most progressive cities in the East.—*Electrical World.*

CHEMICAL SECTION.

Stated Meeting, held March 17, 1904.

Concerning Soils, Germs and Worms.*

By Dr. Persifor Frazer.

In Part III of the Report of the Geology of New Jersey, of 1868, under the head of "Economic Geology," the Director, Prof. Geo. H. Cook, says: "In the detailed geology and under the proper heads, will be found chemical analyses of gneiss, limestone, slate, shale, trap rock, clay, green sand, etc. The soils are mostly derived from these; sometimes from one, and sometimes from a mixture of two or more of them. And this geological classification is the best that can be made. A more common classification is into sandy, loamy and clayey soils. The latter, however, is not capable of general use. The meaning of the terms always depends on the experience of the person who uses them. What in one part of the State is called a clayey soil, in another part is called a loamy soil, and in still other places it would be called sandy," etc., etc. This statement will furnish an appropriate introduction to the observations on soils which are here proposed, since it shows how vague is the average conception of the character of that storehouse whence we draw our life. But the farmer's division into sandy, loamy, and clayey is not more crude than was that of the average geologist. To him soils were but the comminuted rocks of the earth's crust mixed with more or less adventitious organic matter, and moistened by the rain, the dew, and the capillary flow of the ground waters. Professor Cook, as he says, "to show how light or sandy a soil will produce vegetation," instances in the same chapter the following analysis of beach sand from Old Beach, Atlantic City:

* Substance of a lecture delivered before the Pennsylvania Horticultural Society, Tuesday, April 18, 1899, by Dr. Persifor Frazer, Professor of Horticultural Chemistry, Penna. Hort. Soc. Subsequently revised to January 1, 1904, and in part rewritten.

Silicic acid and quartz	95·44
Alumina Peroxide of iron	3·00
Lime	0·45
Magnesia	0·22
Water	0·30
Total	99·41

In the report of the geological survey of New Jersey for 1879, glass sand and sandy clays are noted as producing oak-land and pine-land soils.

How very different is the idea of a soil in the minds of the agricultural chemists of the present day may be judged by Wiley's definition ("Principles and Practice of Agricultural Analysis." Chemical Pub. Co., Easton, Pa., 1894): "The term soil, in its broadest sense, is used to designate that portion of the surface of the earth which has resulted from the disintegration of rocks and the decay of plants and animals, and which is suited, under proper conditions of moisture and temperature, to the growth of plants. It consists, therefore, chiefly of mineral substances, together with some products of organic life, and of certain living organisms, whose activity may influence vegetable growth either favorably or otherwise. The soil holds various quantities of gaseous matter and of water, which are important factors in its functions." Yet it is possible to make plants grow without the intervention of any soil in the sense of the last definition (Storer, "Agriculture in Some of Its Relations with Chemistry"); for not only does the mistletoe grow in the air, but hyacinths, cuttings of rose bushes, *tradescantia*, and Indian corn, or almost any of the ordinary grains, may be made to grow and bear seeds in glasses of water, provided the latter contain some ash-producing material and some nitrates, which are ordinarily derived from the soil. However small the amount, some potash, lime, magnesia, iron, phosphoric, sulphuric and nitric acid (or, in the place of the last, ammonia) must be present in order to develop the plants of the higher orders (id. I).

Soil is necessary as a prop for the plant in nature, as well as a sponge from which to extract the food which is to sus-

tain it; and for certain plants, such as tubers, the light, easily-displaced covering of pure silica sand, when once well manured, produces more perfectly formed plants than the less yielding natural mold.

The passage of water and its saline constituents through a plant, and the evaporation of the former (or, more properly, its exhalation, since the process is connected with the life of the plant and may take place, unlike ordinary evaporation, when the surrounding atmosphere is saturated with moisture), results in an enormous circulation, estimated by Watson at 30 hogsheads of water on every acre of grass land per day. About 300 parts, by weight, of water pass through a plant to one part fixed and assimilated in its tissues.

Ordinary soils contain large quantities of nitrogen; in fact, by a series of experiments on Scotch soils and manures made by Anderson, the average proportion of organic matter in the soils was 7·02, and of nitrogen in this organic matter 0·206; or a relative proportion of nitrogen to organic matter in the natural soil of somewhere near 1 : 35; whereas in the manures applied to the eight farms from which these various soils were taken, the average proportion of organic matter was 13·94, and of nitrogen 0·382. The proportion of the nitrogen to the organic matter in the manures was as 1 : 36·49. Consequently, the relative proportion of this invaluable plant food element was higher in the natural soil than in the manure laid on to enrich it.* Professor Storer con-

* It is interesting in this connection to note the "fertilizing ingredients" and their cost, enumerated by Mr. MacFarlane in his admirable report on "Fertilizers." The quantity of each ingredient in a given fertilizer must, according to Dominion law, be stated by the dealer. (Published by the Inland Revenue Department of Canada, Bulletin 86, Ottawa, 1903.)

Nitrogen in salts of ammonia or nitrates as well as in compound fertilizers	$0 13
Organic nitrogen in ground bone, fish, blood or tankage	12
Phosphoric acid—soluble in water	6
" " " 1 per cent. citric acid	5½
" " insoluble in Thomas' phosphate powder	3½
" " " ground rock phosphate and fertilizers generally	1½
Potash contained in wood ashes	6
" from high-grade salts	5¼

siders the utilization of these natural and almost inexhaustible supplies of nitrogen among the most important of the problems of to-day, and adds that from remote time the improvement of the soil-nitrogen has been deemed, by wise cultivators, more advantageous than employing fertilizers, or keeping additional cattle to produce more manure. These stores of nitrogen are found in arable loam, leaf mold, peat, swamp and marsh mud, etc., and here is where an agent often neglected renders valuable service, as will be seen further on.

The effect of "symbiosis," as Storer calls it, or blended life of various kinds, is well illustrated by the little knobs and warts on the roots of clover and leguminous plants. The most generally received explanation of this phenomenon now is that bacteria enter the roots from the soil, and form colonies within the roots, thus giving rise, by the mutual growth of bacteria and plant-cells, to those excrescences. The lower organisms thrive on the juices of the plant, and in turn render some service in supplying these roots with nitrogen. Hellriegel has shown that nitrogen from the air is stored up for the benefit of such plants, even when the latter are grown in sand free from organic or nitrogenous matter. Nodules form upon the roots at the time that nitrogen is being taken from the air; but material akin to the ash-residue of the normal plant must be strewn with the sand. When growth ceased, in such experiments, occasionally germs from the air fell upon the sand and started the growth anew; but on supplying water, which had been in contact with garden loam and was charged with bacteria, the full and healthy growth was recommenced, and the plants assumed their normal dark-green color. The plants feed upon the substance of the bacteria after the latter have died.

These plants, which get nitrogen from the bacteria, charge the soil with nitrogen to the benefit of succeeding crops of other plants; and this is the modern explanation of the utility of rotation in crops, which has been recognized probably ever since husbandry began. A continuous succession of peas, for example, not only gives rise to nematode

worms, instead of bacteria nodules on the pea roots, but these worms are transferred to the next crop which is put in, and impair or ruin it.

Great lichens, such as reindeer moss, or Iceland moss, grow freely on bare rocks and sterile soils. Fungoid growths are noticed, even covering in a few days surfaces of iron. These fungi produce large quantities of nitrogenous organic matter.

Berthelot showed that certain nitro-organisms living in soil feed on the nitrogen of the air, and produce nitrogen compounds, at first insoluble in water, but later converted into soluble nitrates, to the amount of 75 to 100 pounds per acre per annum.

But the fixation of nitrogen by nitro-organisms in the soil is less important than that by bacteria on the roots of leguminous plants.

The general conclusions as to nitrogen and micro-organisms in their relations to plants, reached through the work of Atwater, Wagner, Heiden, Hellriegel and Wood (of the Storrs Agricultural School in Connecticut), may be thus summarized:

Pease, alfalfa, serradella, lupine, probably clover, and in general all leguminous plants acquire large quantities of nitrogen from the *free nitrogen* of the air during growth.

It is clear that there is a connection between the root tubercles and this acquisition of nitrogen, but what the connection is remains to be discovered.

Cereals which have been experimented with have not shown this power of taking nitrogen, nor had they such tubercles as are found on the roots of legumes.

In the experiments undertaken soil infusions did not seem necessary for the production of root tubercles. It is considered probable that the micro-organisms or spores were floating in the air and thence found their way to the pots in which the plants were growing.

As a rule in the experiments, the greater the abundance of root tubercles, the larger and more vigorous the plants, and the greater the gain of nitrogen from the air.

Where loss of nitrogen occurred there were no root

tubercles. It was largest with oat plants and largest where they had most nitrogen at their disposal in the form of nitrates. The gain of nitrogen in legumes helps explain why they act as renovating crops, and the loss in the case of oats suggests why they should be an exhausting crop.

(MacFarlane, Bulletin 86. Canadian Report I. R. D.)

On barren ledges of rocks the frost and other causes produce disintegration, and the spores of fungi resting on this talus produce nitrogenous matters from the air. The soil is then ready for the next step, which is the making of mold.

Humus, according to Storer, is the organic portion of all the earth-like products which results from the decay of vegetable or animal matters. In temperate climates the tender parts of vegetable matter are converted by the oxygen present into carbon dioxide and water (through micro-organisms chiefly), and the residue is humus, which resists further decay.

The acids of various constitution, together known as humic acid, though not very soluble in water, are chemically active.

Agricultural plants, in general, cannot feed directly upon humus, but, through the micro-organisms which feed on it, are supplied with nitrogen.

Three ferments in all are needed: one to set free ammonia; one to produce nitrites from it; and one to produce nitrates from nitrites. Nitrification is most active in hot summer weather. No nitrates are produced by putrefying processes. On the contrary, nitrates, if present, are converted into ammonia.

In an experiment made by Leone with nitrates and hen-dung in loam, placed in a box so that air could freely pass between the particles, first nitrates were partially reduced to nitrites. In a fortnight both nitrates and nitrites disappeared, and only ammonia was detected. In little over a month, nitrates again began to appear, and in three months there were only nitrates. Lorgna defines nitrification as the last term of putrefaction.

The above experiment shows how easily an injudicious

treatment of a valuable manure may entirely destroy its efficiency. A few words on the value of farm manure and the best methods of securing, preserving, increasing its efficacy, and applying it, seem here appropriate. Hellriegel, in 1897, proposed a simple plan easily applicable everywhere and every year, by means of which a practical agriculturist may see differences between adjacent crops treated differently, and thus decide what should be the substance applied to the soil to insure the best harvest. It is to pass over a few square rods of the field, at various places properly selected, without applying dung or fertilizer. In accordance with this principle other plots of like dimensions may be treated respectively with lime, marl, dung, or fertilizers. The heights and densities of the resulting crops, the fulness of the ears and the development of the grains, etc., may easily be compared, and a correct conclusion drawn as to what is best for that particular soil.

J. Koenig, in his prize essay, "How Can the Farmer Preserve and Increase the Stock of Nitrogen on His Property?" (Berlin, 1887), gives the results of his investigations and experience as follows:

(1) In the decomposition of nitrogenous substances of every nature a loss of free nitrogen, more or less considerable, takes place.

(2) This loss is the greater the more the atmosphere has access to the decomposing mass.

(3) Too much moisture is as hurtful as too little. Stable manure requires such a degree of humidity as permits its components to lie close together.

(4) The addition of substances which fix ammonia (such as gypsum, kainite, and kieserite) prevents or reduces the loss of nitrogen. *These substances are, however, of little or no value if care be not taken at the same time to prevent as much as possible the access of air.*

In storing stable manure, it should be kept in a watertight receptacle, roofed in, and it is desirable that it be trodden down by the farm animals. It is perfectly clear that the use of gypsum or ordinary ground land plaster prevents any loss of nitrogen in the stable, and, according to

Holdefleiss, Vogel, and others, the same substance, or gypsum produced in the manufacture of the acid phosphate, prevents the loss of ammonia from the liquid part of the manure. Another suggestion by Dr. C. A. Goessmann, Chemist for the Massachusetts Agricultural College (Bulletin 45, March, 1897), is that there should be added to the manurial refuse materials of the farm such single manurial substances as will enrich the former in the directions desirable for any particular crop.

(Canadian Inland Revenue Department Bulletin, No. 86, before cited.)

The substance of the following notes on bacteria is taken from an interesting lecture entitled "The Analysis of Water, Chemical, Microscopical and Bacteriological," before the Lowell Institute, Boston, December 5, 1889, by Dr. Thomas M. Drown, then Professor of Analytical Chemistry in the Massachusetts Institute of Technology, now President of Lehigh University, Pennsylvania. In speaking of the bacteria found in the sanitary analysis of potable waters, he says: The bacteria belong to the lowest form of life; a simple cell, with wall and contents, capable of self-nourishment and reproduction. Until within a few years their presence was unknown and unsuspected, so minute are they, and yet their importance in the economy of nature is such that higher life would come to an end if their activities were to cease. It is unfortunate that these ever-present, humble, useful organisms should be associated in our minds mainly with evil purpose and effect. True, there are malignant bacteria, to which we cannot assign any beneficial role in nature; but so there are poisonous fruits.

The bacteria, or germs, as they are also called, have many shapes; the ball or egg-like forms include the genera micrococcus and streptococcus; the rod-like forms, the genus bacillus; and spiral forms, the genus spirillum. A special form of bacteria we have all become familiar with in name —the cholera germ, called by Koch the comma bacillus.

The function of the green plant is to make organic material out of the inorganic. Trees, grass, and vegetables

live entirely on the carbonic acid of the air and the water and mineral matters in the soil. Animals cannot do this, but require either vegetable or animal food. In utilizing this food, the animals do not reconvert it all into mineral matter again. The nitrogen in the proteid, or albuminoid matter which they consume, is not excreted in the oxidized form of nitrates, but as urea, a compound related to ammonia. Then the bacteria step in, find food for their support in the waste which has no more value for animal life, and complete its conversion into mineral matter that it may again serve as food for plants.

The method employed to determine the numbers of bacteria is based on the principle that by stimulating their growth and making them increase enormously within a small space, in which they cannot move, the aggregations of the newly developed bacteria will be so large that they can be seen by the naked eye. This ingenious suggestion was carried out by the famous bacteriologist, Koch, in this way: A small quantity, usually 1 cubic centimeter, of the water (that is, about one-fifth of a teaspoonful) is mixed thoroughly with, say, ten times its amount of a sterilized solution of gelatine, which contains extract of beef, peptone, etc., to make it highly nutrient, and the mixture is poured, while warm, upon a glass plate, so that it forms a thin layer when solidified. This is set aside for a few days in a warm room under a cover, and protected from the germs in the air. If bacteria are present in the water they will grow with great rapidity under these conditions, each bacterium forming a colony, as it is termed, of thousands or millions of bacteria. Then we can see and count them. It is assumed that each colony arose from a single bacterium in the water; hence, by counting the number of colonies on a plate, we arrive at a determination of the number of bacteria in the cubic centimeter of water used.

The numbers of bacteria, as determined in this way in natural waters, vary greatly. A water taken directly from the ground, at a depth of six feet or more, should contain none. In good pond waters may be found anywhere from a few score to a few hundred. In polluted streams they may

run up well into the thousands or hundred thousands, and in sewage they can be sometimes counted in the millions. Organic matter is composed of carbon, hydrogen, oxygen, and nitrogen; at least, for our purpose it will suffice if we so consider it. It is only the nitrogenous organic matters which undergo those kinds of changes which we include under putrefaction, and which we regard of importance from a sanitary standpoint. Familiar examples are milk and meat, which, when exposed to the air, become offensive, but starch and sugar (which contain no nitrogen) do not.

The nitrogen which we find on analysis from undecomposed animal and vegetable matter, say fresh albumen, we call "organic nitrogen," by which we mean that the nitrogen is still in its original combination before change or decay has set in. Leaving out of consideration that present in rain-water, we may say that ammonia in water is distinctly characteristic of the first stage of the decomposition of organic matter. The term "organic nitrogen" has been used, but on the tables of analyses another is substituted, namely, "albuminoid ammonia." It is an unfortunate fact that the methods of determining organic nitrogen have been, until recently, very tedious and difficult, and not always reliable, so that chemists have resorted to another process, which gives only a part of the organic nitrogen in the form of ammonia. That is called albuminoid ammonia, because albumen, when subjected to this process, gives up its nitrogen as ammonia.

From the present methods of examining water the following facts are ascertained. (1) By means of the microscope, the kind of life existing in the water, from which conclusions are drawn as to the kind and quality of the food which supports this life. (2) By means of the gelatine plate cultures, the number of the bacteria in the water, from which conclusions are drawn as to the amount and kind of decay going on. (3) The purely chemical examination reveals directly the amount of organic matter, and the conditions in which it exists. These widely different methods are merely different points of view. It is one and the same thing throughout, namely, the life processes which are

going on in the water; for decay is but the manifestation of another form of life.

If it is asked why study is centered here, the answer is, simply, that experience has taught that it is the organic matter which is the cause or accompaniment of disease; it is during the decomposition of this organic matter, and in some of the changes it undergoes in the process of decay, that danger lurks. This is the chemical expression of the causation of disease. The biological expression takes another form, namely, that the bacteria which cause changes in the organic matter cause also disease. The two expressions do not contradict each other, but go hand in hand. The chemical idea implied in both expressions is that the state of change is the state of danger. From an horticultural point of view, the state of change is the state of evolution.

The vegetable mold which forms the rich top-soil of every agricultural country consists of a very uniformly fine mass of blackish color, usually only a few inches in thickness, though under exceptionally favorable circumstances it may reach a depth of nine or ten inches. Humus (of which there is a surprising lack of definition in the best works, but which is generally understood to be earth more or less charged with decaying organic matter) is well illustrated by beds of peat and so-called muck. The latter term, however, according to Storer, is misapplied, and should mean "well-rotted dung" (II, 78), though in this country, and especially in New England, it is synonymous with marsh mud. The vegetable mold, if not coincident with, at least contains the greater part of the humus in a given area, and it is in this that the germination of seeds and the growth of plants have their best development.

The humus has been investigated by our countryman, Prof. A. A. Julien ("On the Geological Action of Humus Acids." Pr. A. A. A. S., XXVIII, 1879, 311), by whose labors it is established that there are many acids of complicated constitution confounded under the name humic acid. All of them act energetically upon rocks, and perform important functions in the preparation of the material

with which they come into contact to facilitate plant growth, directly through the disintegration of leaves and animal tissue, and indirectly by furnishing food to the bacteria which are so indispensable to vegetable life.

Charles Darwin, among the countless contributions of this greatest of naturalists to our understanding of nature, has observed ("The Formation of Vegetable Mold through the Action of Worms," etc.; Appleton, 1882) that the upper part of the intestines of earth worms generates the several humus acids which are produced by decaying vegetation. The calciferous glands lying below this tract produce a material which neutralizes the acids thus generated, for the digestive fluid of worms will not act unless it be alkaline. These acids, he thinks, are generated during the digestive process, and are probably of nearly the same nature as the humus acids, so that the agency of worms in producing the material out of which that of plants is assimilated is evident. The action of worms is not confined to chemical changes, but extends in many widely different directions, and, according to this accurate observer, is stupendous in its results. At the risk of repeating what is familiar to many of you, I will sketch briefly this action as epitomized in the work just cited. There are but few genera of earth worms distributed throughout the world. Their mode of life is to burrow in the ground, which they do by eating a hole through the soil, and with the mouth filled, advancing the œsophagus, thus forcing the cheeks outward in all directions, crowding the soil aside, and enlarging the burrow. ("The Soil," etc., F. H. King, Professor Agricultural Physics in University of Wisconsin; Macmillan & Co., 1896.) The material swallowed is passed through the calciferous glands lying midway in the œsophagus, where the acids are neutralized; through the crop and gizzard, where the particles are triturated by the hard stones habitually retained there; and into the intestine, where the pulp is again made acid; whence, at the mouth of the burrow, it is voided in the form of castings or worm-dung in piles of greater or less size, and more or less retaining the mold of the intestines. The castings may be seen after a

rain, especially in gardens and much-frequented walks. Earth worms work preferably at night, and lie close to the mouths of their burrows by day. The mouth of a worm is situated at the anterior end of the body, and by means of a lip the animals can grasp an object and draw themselves forward. Their intestine has a deep involution of its walls, by which additional absorbent surface is gained. They breathe through the skin. They are destitute of eyes, but conscious of a bright light and sensitive to it in the anterior part of the body. They are less sensitive to radiant heat. They are very sensitive to touch or vibration, though not to sound. Their perception of odors is feeble, but enough to direct them to objects which they like to eat (cabbage leaves, onions, etc.).

They are omnivorous, swallowing everything they can grasp, and extracting what nutriment the mass contains. Their preference is for half-decayed leaves, however, which they draw into their burrows partly for food and partly to close the entrances; and to this circumstance is due much of the finest soil which they produce.

They moisten the objects with a secreted alkaline fluid like pancreatic juice. The calciferous glands are probably fed with lime by the leaves in which this earth concentrates before they fall. This is excreted as carbonate of lime and aids the digestive process. The castings of worms are usually acid. Darwin concludes that they possess a low order of intelligence, in contradistinction to instinct. His experiments on this subject are very curious and instructive. With worms kept in a pot he observed the manner in which hundreds of objects of different shapes were drawn into their burrows, which are thus lined, he thinks, on account of the sensitiveness of the animals to cold, for the purpose of avoiding the contact of their bodies with cold, damp earth. The amount of work performed by worms is measured by the rapidity with which objects laid on the ground become covered by their castings. There are instances of coal ashes, strewn over a large field, which were buried in this way 7 inches in eighteen years. The tesseræ of pavements, ancient buildings, large stones (including some of

the Stonehenge), ancient walls, etc., are found to be covered to a greater or less depth by the castings of earth worms, and independently of the action of other agencies. With this, of course, is to be reckoned the sinking of these objects through undermining by worms, and the subsequent colapse of the burrows. The soft mold removed from lower levels to the surface has passed repeatedly through the intestines of worms, and much of it has been finely triturated in their gizzards. Darwin estimates that, in each acre of earth which is sufficiently damp and not too sandy, gravelly, or rocky for worms to inhabit, a weight of more than 10 tons of earth annually passes through their bodies and is brought to the surface. The result for a country of the size of Great Britain in, say, a million years, is 320 million million tons of earth in land which is cultivated and well fitted for these animals. It is probable, he thinks, that all of the finest vegetable mold which we see has passed again and again through the bodies of earth worms.

There is a series, and perhaps a cycle, of changes from the partially cooled, still incandescent mass, and newly formed planet—the Earth*—to the well-cultivated hive of industry of to-day; teeming with millions of workers prosecuting countless industries, all of which depend upon the

* A new view of the evolution of our planet eliminates incandescence and change from gas to liquid and from liquid to solid during the earth's history. [T. C. Chamberlin, *Journal of Geology*, vi, 609; vii, 545, 667, 752. H. Le Roy Fairchild, *Bul. Geol. Soc. Am.*, vol. xv.] According to the modern substitute hypothesis the discrete matter derived from the hot nebular ring was cooled before it aggregated to form the earth. But even if this new view should ultimately displace the assumption that the earth was a hot fluid ball, which so many distinguished geologists have considered the necessary consequence of La Place's Nebular Hypothesis, it will not in any way affect the proposition of the interdependence of various forms of life herein stated. Neither the old nor the new hypothesis of the origin of the earth pretends to account for the advent of life, and its dawn is almost universally ascribed to a time when the surface of the planet was not greatly warmer than it is now. The only difference is that the new theory gains the disposal of an immensely greater period of time during which this earliest life may have been evolved into the many forms existing to-day, and shakes itself clear of the fetters which Lord Kelvin and other physicists have put upon geological speculation. Professor Fairchild's plea is "Geology for the geologists!"

change of form of the materials which the earth furnishes, sometimes for the sake of these new forms, and sometimes for the sake of the forces which are incidentally generated; but all of which are made possible by the life which the earth gives to the workers through the products of its soil.

(1) There was the partially cooled, lava-like crust of the earth, glowing cherry-red, and surrounded by the heavy acid vapors and steam, wherein the volatilizable oxygen compounds of sulphur, phosphorus, nitrogen and the like, known as sulphuric, phosphoric, and nitric acids, pervaded and gave their acid character to the dense, inky clouds of steam mingled with all other but the most unvolatilizable terrestrial elements.

Finally, when additional cooling had taken place, these acid vapors condensed and descended in torrents which excoriated the vitreous mass, and sent floods of highly saturated solutions into its natural depressions—the first commencement of a sea. The waters heretofore enveloping this planet in clouds like those of Mercury and Venus, descended in great mass and deluged the basaltic crust, cracking and comminuting it, and thus offering the acids more favorable opportunities to attack and dissolve its substance; tearing away its salient prominences by crush of flood and gale; spreading out the debris as a slime, mud, or sand in the natural channels; and carrying the finest suspended particles into the sea. At last, the alkaline ingredients neutralized the acid waters, and the ocean contained only highly diluted neutral salts.

The contraction of the nucleus produced new elevations and depressions, changing the old ones; so that continuously the bottoms of the seas emerged and became dry land, and high ridges were depressed under the surface of the waters. Somewhere, either at this period or perhaps from the very beginning, appeared the force we call life because we cannot understand it; and in all probability its lowest known form—perhaps some sort of bacterium. The derivation from this simplest life-element of the lowest life-kingdom we recognize—that of plants—is not yet understood, but the advance accomplished, as always occurs in nature,

the plants assisted, and were assisted by their predecessor in form, until still further progress was made; each stepping-stone being used as a support to place the next, while the old were not destroyed; just as a man flings blocks into a stream to cross dry-footed, and stands on the last he has planted to place the next.

Then plant-growths imperceptibly changed in complexity and character to the second and highest life-kingdom—that of animals; but so insensibly, and with so many interlocking characteristics among the beings which are found on the border line, that no definition has yet been found which can quite satisfactorily indicate the distinction between animal and plant, nor between plant and mineral, nor between vital and any other kind of force.

Taking the sequence of events as they are, the infinite variety of plant and animal forms, from the minutest unit capable of being seen under the microscope to the gigantic California redwood, and the elephant, the lower forms and forces act as servants to the higher. The winds and frosts still tear new mineral matter apart, and the rivers and ocean grind, sift, and spread it into gently sloping prairies. The micro-organisms and the fungi invade this material, and, reaching to the atmosphere for the organic elements which it contains, translate this carbon and nitrogen into lichens, moss, herbs and humus. But with this advance in the vegetable world an advance in the animal world has taken place *pari passu*, and, amongst other useful forms, the worms appear as husbandmen and workers of this crude mass into soil fit for the highest plants. Again and again this comminuted dust, with its bacteria, goes through the alimentary canal of the worm, and is spread over the surface, hard or soft, sterile or fertile alike, hiding the floor of our planet under the rich banquet which these humble creatures spread out for higher forms of the lower kingdom.

Upon this spring the grasses and grains, the bushes and trees, which in turn send down their roots through the soil, and, saturating the unaltered crystalline rocks with their acids, prepare new material for the steps of preparation

which have been described. On the higher forms of plant life the highest forms of animals live, the highest as well as the lowest representatives supplementing their simpler diet by feeding on each other.

The processes are so various, the change of action so incessant, and in such endless rotation from purely physical or chemical to vegetable and animal, that one is unable either to specify in what resides the high and the low in nature, or wherein the forces or the forms we recognize in the three kingdoms differ from each other fundamentally, in spite of the superficial differences which appear to our senses.

THE INVENTOR OF THE DYNAMO.

Dr. H. Wilde has brought an action to restrain Prof. S. P. Thompson from referring, in books of which he is the author, to certain electrical machinery as being "dynamo-electric machinery," Dr. Wilde himself claiming the distinction of being the inventor of the dynamo and dynamo electric machinery, and objecting to the invention being accredited to any one but himself. The lower court and the appeal court decided in favor of Thompson. In the same impression of the London *Electrician* from which the foregoing is gleaned there is a long letter by S. P. Thompson on the definition of a dynamo. The word is used by authoritative writers in two different senses, either in the narrow sense of the self-exciting machine or in the wide sense, including all machines in which mechanical movement is used to generate an electric current, only the electrostatic class being excluded by common consent. On the other hand, what Dr. Wilde had in effect sought by his suit, was to force everybody to employ the term dynamo only for separately-excited machines.

GARBAGE DISPOSAL AND THE HARBOR CHANNELS.

A strong argument for the rational treatment of garbage accumulations of larger cities is contained in the following editorial comments of the *Scientific American* on the consequences of dumping the refuse of New York City in the waters outside of Sandy Hook.

The United States Government is engaged in dredging a great 40-foot channel from deep water off Sandy Hook to the Narrows within New York Harbor. If a 40-foot contour line were drawn on the chart, it would be found to extend across the harbor mouth well inside of Sandy Hook lightship; and when the channel is completed, incoming vessels of the largest size will be able to sail from deep water to the Narrows without any of the tortuous and difficult navigation which at present is a source of more or less anxiety to incoming vessels, especially if they happen to be of the draft and length of our largest trans-atlantic liners. Unfortunately, the success of the scheme is menaced by the fact that the waters outside of Sandy Hook are used as a

dumping ground for city refuse; and the enormous amount of refuse that is unloaded year by year from the city's scows would seem to be at last producing the disastrous results which have been feared by those who are interested in preserving unobstructed navigation into this harbor. A Sandy Hook pilot recently reported that in several places south-southwest and south-southeast from the lightship, and within a radius of ¾ of a mile, the cast of the lead showed only 7½ fathoms where from 11½ to 16 fathoms are called for by the chart. Here is a matter that demands the immediate attention of the Government. Seven and a half fathoms is within 5 feet of the depth to which the new channel is being dredged, and if this shoaling up is due to the dumping of city refuse it may be taken for granted that the formation of these shoals will be continuous. As matters now stand it looks as though we were undoing with one hand what we are doing with the other. In any case, the present method of garbage disposal is an extremely crude and provincial one for the metropolis of the western hemisphere. It is also distressingly "sloppy" and untidy. The neighboring shores of New Jersey give evidence of this, for they are adorned with a variegated fringe of domestic refuse and "cast-offs" that would do credit to the back alleys of a western mining camp.

RECLAIMING MARSHLAND.

A great deal of northern Minnesota is about as flat as a floor. Over a wide area east of the Red River Valley the water partings between the streams are scarcely perceptible. Many of the streams meander in tortuous courses sluggishly over the prairie and lose themselves finally in big marshes. Some of the rivers, as shown on the maps, appear suddenly to terminate just as rivers are marked on maps of deserts where the streams are lost in the sands.

According to the New York *Sun*, a number of these large marshes are not far from the Red River Valley. It is proposed to dig some long ditches to lead the waters of these now sodden and worthless lands into the valley. The Lost River ditch will be four miles long, and will drain 22,000 acres of swamps; the Badger ditch will be eight and a half miles long, draining 5,300 acres; the New Solum ditch will be four miles long, draining 1,000 acres; the Goodhope ditch, five miles in length, will also drain an important area.

The total cost of these four ditches is estimated at $26,500, and they will turn 30,000 acres of swamp lands into the richest of fields and meadows, adding most appreciably to the productive area of the State, and improving the health conditions in that part of the country. The contractors have already begun the work on these important improvements.

TIN MINING IN SOUTH CAROLINA.

Outside of Alaska the only tin mining in the United States at present is found at Gaffney, in the northwestern part of South Carolina, near the North Carolina line. The first shipment, amounting to 20 tons, of tin ore from this Gaffney deposit has just been made by S. S. Ross, the ore going to England. This deposit is a continuation of that at King's Mountain, in North Carolina, which was opened fifteen years ago by Mr. Richard Eames, Jr., and which at that time produced some high-grade cassiterite.—*Engineering and Mining Journal.*

ELECTRICAL SECTION

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

By W. E. Harrington.
General Manager Camden and Suburban Railway Company.

(*Concluded from p. 230.*)

SPECIAL RAIL BONDING TOOLS.

Figs. 67 to 71 exhibit a series of special rail bonding tools designed for placing amalgamated bonds.

AJAX BOND.

The Ajax bond consists of a sheet or piece of copper, contacting with the web of rail on each side of joint under the fish plate or joint, held up and against the web by set screws, cupped hardened ends, set screws set in fish plate or joint; usual method is to insert a sheet of steel between copper plate and points of set screws. The web of rail having been ground off and treated with Edison-Brown alloys, as well as the side of the copper plate contacting with rail, the result is to all intents and purposes a knife-blade switch. In all cases where the Ajax bond has been installed and action and life observed, it has invariably shown a very satisfactory condition.

Test No. 11 shows 90 per cent. resistance, three years life.

It might be interesting here to mention other makes of bonds more or less in use, some of which have fallen into disuse, either from inefficiency or interested parties discontinuing manufacturing:

Johnston bond, West End bond, Bryan bond, Columbia bond, Channel Pin bond, Forest City bond, S. H. Harrington ball bond, S. H. Harrington diagonal bond, Grauten bond,

Stern & Silverman bond, Payne welded bond, Atkinson bond, Syracuse bond.

CAMDEN AND SUBURBAN RAILWAY BONDS.

The C. & S. bonds shown in *Fig. 73* were designed by the writer and intended to provide large, ample contacts. The

FIG. 67.—Portable grinder.

No. 1 C. & S. bond consists of a square copper casting with two grooves for 4/0 B. & S. gauge copper wire; casting has a $1\frac{1}{16}$-inch hole in center. A cast-iron casting with corresponding grooves and hole is provided. The bond is

applied by grinding off the web of the rail with an emery grinder and treated with Edison-Brown alloys, serving to amalgamate the surface of the rail and fill valleys and depressions and irregularities of the surface, the 4/0 wires and the copper casting grooves are also treated, the whole is then bolted to the web of the rail with a 1-inch bolt, using

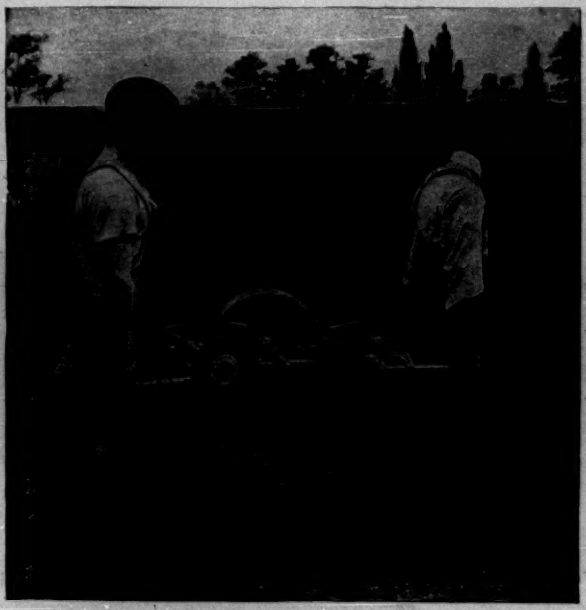


FIG. 68.—Portable grinder.

a lock washer. The bond plates are located each side of the fish or joint plate and are connected by two 4/0 wires.

The No. 2 C. & S. bond is similar to the No. 1, only that it is larger and is bolted to the rail with two 1-inch bolts.

The No. 3 C. & S. bond is similar in general design to

the No. 1 and No. 2, but differs in that only one No. 4/0 wire is employed, and is twisted in a circular loop at ends to fit in a circular groove in bond plates, the copper and iron plates are drawn to the web of the rail by one 1-inch bolt with lock washers.

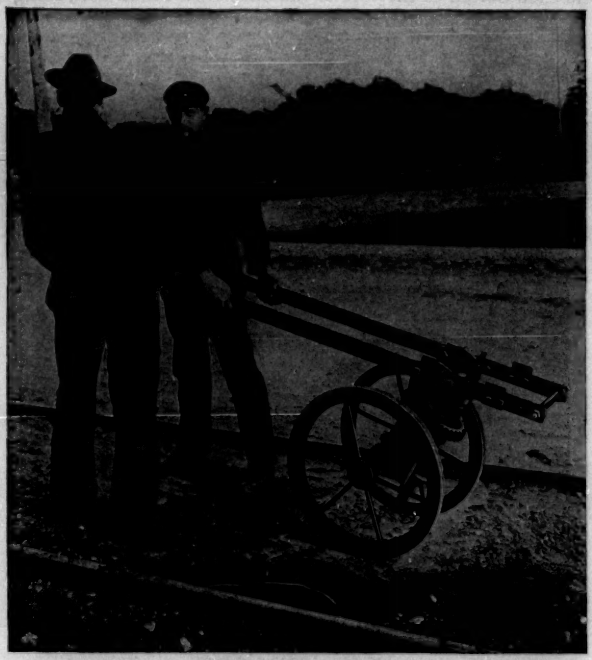


FIG. 69.—Portable grinder.

The No. 3 bond has been principally employed on tee rail, although it is as well adapted for girder rail.

The following cut (*Fig. 74*) illustrates ten types of bonds tested at random, and shown in detail after having been tested. The method of testing (*Fig. 75*) was exceedingly

simple and is described below under C. & S. testing. The column marked "Ratio of Conductivity Bond to Rail" (*Fig. 75*) simply indicates the percentage of resistance that the 3 feet of rail, including joint, bear to 3 feet of solid rail sec-

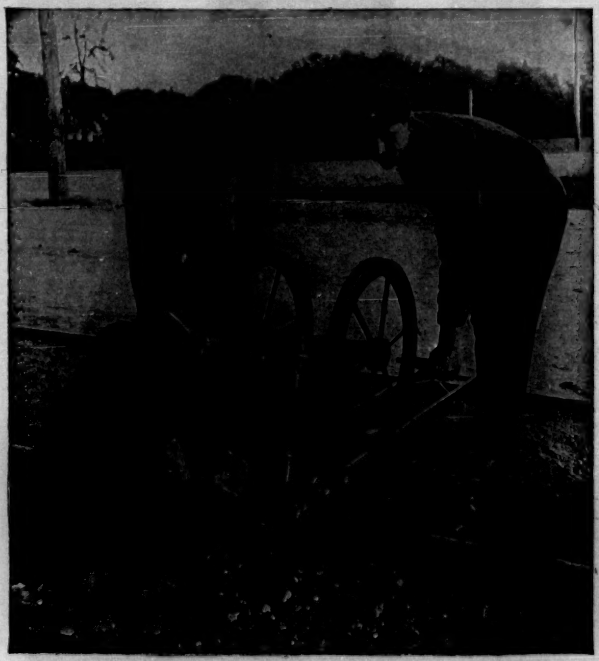


FIG. 70.—Portable drill in operation.

tion. It will be noted that the tests make a very gratifying showing.

No.	Per cent.	Years.
1	43	4
2	55	3
3	40	2
4	55	3

No.	Per cent.	Years.
8	43	5
9	66	7
11	90	3

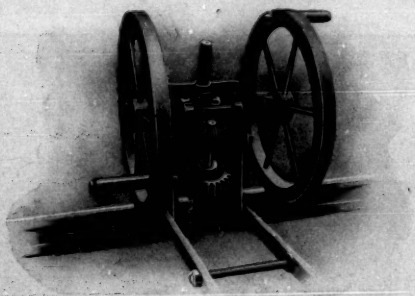


FIG. 71.—Portable drill.

The other tests show over 100 per cent., ranging from 125 per cent. in test No. 10 to 312 per cent. in tests No. 6 and No. 7.

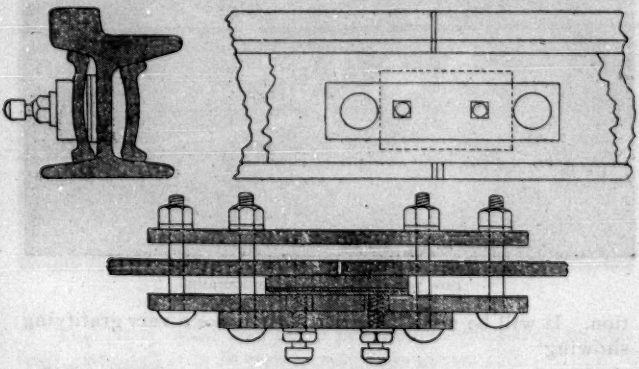
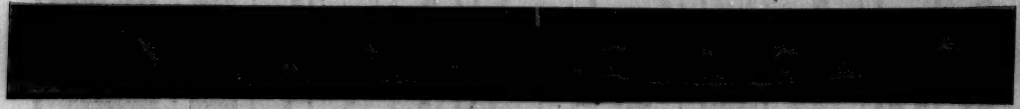


FIG. 72.—The Ajax rail-bond.

It is well to state here that it is a well-known fact, and the observation of all engineers, that successful results can-

No. 1 C. & S. bond.

No. 2 C. & S. bond.



No. 3 C. & S. bond.

FIG. 73.

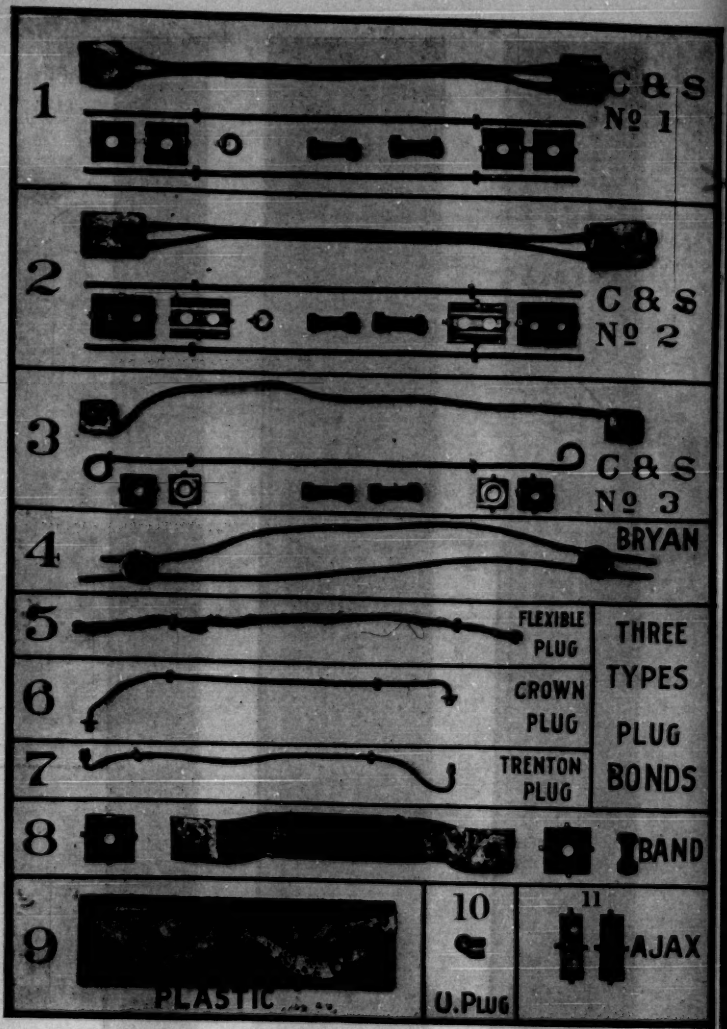


FIG. 74.—Ten distinctive types of bonds.

BOND TEST

C. & S. RWY. CO.
SEPT. 13, 03.

No. of Rdg.	Location of Reading	Trade Name of — Bond —	Trade Name of Rail Section	Line Voltage	Amperes Used	Fall of Pot. in 1 Foot Section of Rail	Resistance of 1 Foot Section of Rail Bond	Ratio Conductivity Bond to Rail	Date Rec'd	State Joint
1	Ash Below 3rd St.	Carbon & Surburban No.1	5" Girder A.S.Co. Sec. 220	550	200	28	12	.43	1899	Regulation Fish Plate
2	5th St. Above Bridge Av.	Carbon & Surburban No.2	5" Girder A.S.Co. Sec. 220	545	220	27	15	.55	1900	"
3	Main & Second St.	Carbon & Surburban No.3	4½" T Rail A.S.Co. Sec. 227	540	150	30	12	.40	1901	"
4	Ash Ave. 4th St.	Britain	7" Girder A.S.Co. Sec. 220	550	200	25	14	.56	1900	"
5	City Limit & Woodchuck Av.	Keystone Plug	4½" Wharton	425	140	40	80	2.00	1900	"
6	Hogsback Rd. & City Limit	Crown Plug	6" Wharton	430	150	24	75	3.12	1896	"
7	Hogsback Rd. & City Limit	Thornton Plug	6" Wharton	430	155	25	78	3.12	1898	"
8	Anderson St. West of Bridge	Chet Weld & Plate	5" Girder A.S.Co. Sec. 220	555	200	28	12	.43	1896	Chet Weld Wharton
9	3rd St. Above Bridge Av.	Plastic Epoxy - Bonded	5" Girder A.S.Co. Sec. 220	550	200	27	18	.66	1896	Regulation Fish Plate
10	7th St. Av. B. Van Hook St.	Flexible "U" Plug	7" Girder A.S.Co. Sec.	460	180	28	35	1.25	1899	"
11	Federal St. East of Bridge	Weld —	9" Girder A.S.Co. Sec. 220	560	160	20	26	30	1900	"

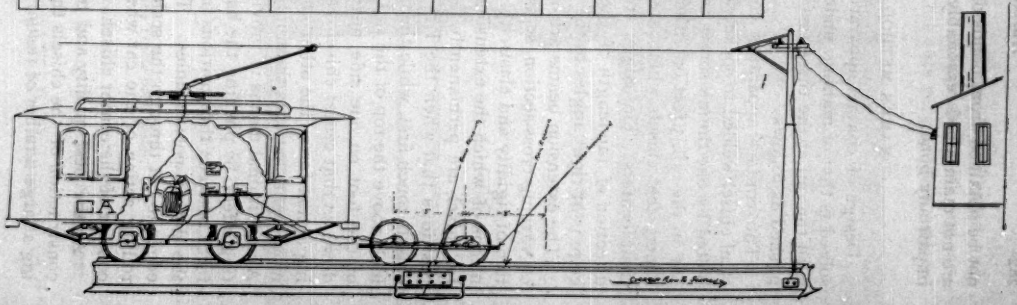


FIG. 75.

not be obtained from bonds on track where the rail joints are not maintained reasonably tight. A loose rail joint will impair any bond.

CONANT'S METHOD OF BOND TESTING.

Design of contact apparatus. The chief problem to be solved is that of making, under all conditions, good contact with the rail at the three test points. This has been accomplished as follows:

The contact apparatus consists of a center pole with steel chisel welded to socket at its lower end, to which are bolted by one thumb-screw, two extension beams reaching out on the rail, 3 feet on either side. These carry two hardened steel chisels which are sharpened so as to bear at their centers. The edges are set so as to extend in the direction of the length of the rail, while the center chisel edge is at right angles to the rail length.

The extension beams are of very tough and elastic wood, of varying cross-section, so as to secure the best combination of rigidity and elasticity. The wrought steel knees, by means of which the extension beams are bolted to the center chisel, are permanently fastened to the beams in such positions that when the T is placed on the rail, the outer chisels touch first, while the center chisel edge is about an inch above the top of the rail. Then, by resting the hollow of the foot on one side, near the center, the T is sprung down so that center chisel rests firmly on rail. This springing action forces the other chisels outward with a scraping movement that cuts them into perfect contact with the rail. An additional means is provided for intensifying this cutting effect, by pushing the handle of center pole back and forth between the positions indicated in the photograph by the dotted pole handles. This causes both outer chisel edges to cut through the scale on the rail produced by the rolling action of the car wheels, but does not disturb the contact of the center chisel.

As the best quality and temper of steel is used in the construction of the chisels they will retain their edge during a large number of tests.

The device for sharpening them is simple and rapid, and consists of a small flat stone that is furnished with and carried in case of instruments. This cuts very quickly, and to

FIG. 76.—R. W. Conant's T-pole bond tester.

stone up the chisel is but the work of a few minutes, as they do not have to be removed or in any way disturbed from their places.

The contact apparatus is portable and self-contained. By

loosening one thumb-nut the outer beams are brought up to the center pole, making it very easy to carry.

Method of testing. With the T-pole connected to instrument and telephone in position, the operator places T-pole on rail with rail joint about a foot from the center chisel. The instrument is started by its release switch at the side and the balancing switch is placed on point numbered 1.

A roaring sound in telephone indicates that balancing switch is to be moved to point of silence. When this has been done the number at which switch stands is read off This number shows the value of resistance of the rail joint in terms of the standard length of rail spanned, which is 3 feet.

For example, if the point of no sound is found, then the resistance of rail joint is equal to twice the 3-foot length mentioned above, or 6 feet of rail. This indicates a fair condition of bonding, bad joints running considerably above this amount. As it takes but a moment to shift the switch completely around its circle, the test of a joint is made very quickly.

C. & S. TESTING.

C. & S. method of testing. The method employed by the Camden & Suburban Railway Company for all its ordinary testing, is with a car having mounted therein a barrel of water, rheostat included in circuit, a Weston ammeter, also a Weston voltmeter, to obtain line voltage. A small truck with wood framing having two axles and 33-inch wheels on 3-foot centers, with a Weston milli-voltmeter located in car and having its terminals connected to the axles of small truck, the car is run so that the small truck will trail between car and power station. As all readings are taken relatively, that is, comparing readings of equivalent joint lengths and solid rail lengths, nothing need be done except to run and make notes. If, however, any unusual reading arises the joints may be tested separately by raising and insulating the wheels of the small truck on the rail; measurements are not desired to be made.

In many cases ordinarily all that may be used is a Wes-

ton voltmeter taken around by a man and a boy with leads to compare drop around joint with solid rail.

In addition to the above, at reasonable intervals the bonding of a railway should be inspected, tested and reported upon with suggestions from some good recognized engineering expert.

Frequent tests over a system is positively necessary, as defects will develop, notwithstanding what form, kind or make of bond is employed. Loads will change, service increases or grows, track becomes worn, special work gives out, underground piping is changed, modified or increased. Perhaps one of the weakest features in bonding is over railroad crossings, and around special track work—too much care cannot be exercised at such places. As a rule, look for high resistance at such places, and particularly where low joints are observed.

Railroad crossings and special work are peculiarly easy to guard. It has been the practice of the writer for some years to cross bond from one side of a railroad crossing to the other, using 4/0 insulated W. P. wires in sufficient number, proportioned to the load, and carried under the railroad tracks in a terra-cotta pipe.

As to the question of concealed or exposed bonds, this question must be settled purely by the environment and conditions under which the track is to be bonded.

An exposed bond, while subject to theft on open-track work, has many advantages when it can be employed, in that it is always subject to quick inspection.

As the real figure of merit of a bond is its life and low resistance, the exposed bond has the advantage of longer life and to all intents and purposes no material difference in resistance in comparison with the concealed.

In paved streets, the question of exposed or concealed bonding in the writer's opinion is not to be considered, as it resolves itself into solely a question of life, conductivity and cost, design being of last importance, design only entering into the question as a matter of final detail when considering the character of joint- or fish-plate.

In conclusion, the writer wishes to emphasize the follow-

ing facts as the results of his observation and experience. (1) In considering any bond, observe always:

Resistance	Obtain actual resistance data. Figure costs to obtain same. Conductivity compared with other bonds. Usually compare 3 feet of rail, including joint, with 3 feet of solid rail section.
Life	Study life of bonds, behavior under practical operation. Make frequent inspection of bonds in service.
Tests	Have frequent tests made on bonding. Look for trouble at all special work and low joints.

The writer wishes to acknowledge the courtesy and kindly spirit shown by the following manufacturers and engineers in furnishing data for this paper:

Mayer & Englund, Ohio Brass Company, American Steel Wire Company, Chase-Shawmut Company, Harold P. Brown, R. W. Conant, General Electric Company, Ajax Metal Company, Albert B. Herrick, H. A. Johnson.

In addition to this paper, the writer wishes to add thereto as an appendix a communication from Mr. A. B. Herrick, consulting engineer, describing his testing apparatus; an article by Mr. Harold P. Brown, describing evolution of bonding; and to refer to the very complete rail bond catalogue, dated June 1, 1902, issued by Protected Rail Bond Company of Philadelphia, which is replete with engineering facts and data, and supplemented by an article contained therein from the pen of Mr. A. B. Herrick, consulting engineer, of New York.

APPENDIX.

ROCHESTER, N. Y., September 14, 1903.

W. E. Harrington, Manager Camden & Suburban Railway Company, Camden, N. J.

DEAR SIR:—In answer to your favor of September 8th, I enclose herewith the photograph of my autographic recording apparatus. The method of operating is as follows: the fall of potential on each rail is taken by two sliding brushes 4 feet apart on each rail. In order that there may always be current present on these rails, a transformer is used which gives me about 200 amperes on each rail. The drop from these rail contacts are taken to two Weston milli-voltmeters, which have a commutator over the scale which they pass, and these hands bridge a spark gap, which spark is conducted to the surface of the record paper, which record paper moves at the rate of 1 inch

per 100 feet traveled by a test car, and the spark traces the record of the movement of the hands at every instant as the car progresses along the track. The height of the deflection of the mark line on the record, when the brushes pass over a joint in the rails, gives the resistance of the joint in terms of 4 feet of rail.

There is also, in order to protect these instruments, an automatic relay which cuts out the instrument when it reads beyond an adjustable point, which is changed depending upon the current density required for the rail to carry at the different portions of the system. When this relay operates, it also moves a pen and indicates a poor bond at that point on the record, there being provided a pen for each rail. The way these bonds are located on the record is by means of a third pen, which draws a continuous line which is open from one curb to the next in case of street intersections, crossings or special work, and, immediately after this location is given, a number is telegraphed by the side movement of the pen, which corresponds to the number assigned to this intersection or special point of location. In this way any bond can be located by measuring on the scale of 1 inch to 100 feet on the record. In interurban work when the automatic moves, it also actuates electrically-controlled valve, which squirts whitewash or paint on the track at the poor bonds.

Briefly, my experience in bonding rails is that in the cast weld made since 1898 the bond at the beginning of the pour is of lower resistance than a 90-pound rail of the same length as the weld. At the end of the pour it runs up to 3 feet of the 90-pound rail. The electric weld is much more uniform as now made by the Lorain Company, and is less than the equivalent length of rail over which the connection is made. In flexible bonds with solid head terminals, those put in by means of compressor giving an effect of compression of 30 tons have lower initial resistance than any other mechanical method of connecting the bond to the rail, and when the flexible portion is cast into head portion, it shows greater permanence under poor track conditions than any other method used in constructing these bonds. The bond soldered to the rail, where the laminations are presented edgewise to the ball of the rail, shows the best form of this construction, but I have not had a life-test on these bonds.

Hoping this data will be useful to you, I remain,

Yours truly,

(Signed) ALBERT B. HERRICK.

RAIL BONDS AND ELECTRICAL CONTACTS FOR HEAVY CURRENTS.

BY HAROLD P. BROWN.

The writer has given very careful study to this subject and, as is shown by papers read before this Institute in '96 and '97, has always advised heavy bonding and low contact resistance.

These views were at first received with a smile, since it was only a few years ago that the leading street railway electricians felt perfectly satisfied with their track circuit after burying a No. 2/0 copper wire under the right of way and connecting it to each rail with a No. 0 tap and a channel pin Many of these gentlemen would tell you seriously that the earth was a " reservoir

of electricity," or a "conductor of infinitely low resistance," and that therefore a No. 2/0 wire was more than sufficient to do the necessary work.

They were surprised to find after a very short service that their "supplementary wire" had practically disappeared, and the remedy for this disappearance was supposed to be found in the use of tinned copper wire. Later the "supplementary wire" was definitely abandoned and scraps of No. 2/0 trolley wire were used as bonds around the angle plates by means of handy but deceptive channel pins.

Still later bonds of wire were made with enlarged terminals which were riveted into holes in the rail. This riveting was slow work and gave unsatisfactory results, and the next step in advance was what is known as the "Chicago" bond, whose enlarged terminal was expanded into a hole in the rail by driving a tapered steel pin into a cylindrical hole in the center of the bond terminal. At first these pins were driven from the side of the rail opposite the bond which was held in place during the driving by a suitable lever or clamp.

The next improvement in this type of bond was driving the pin from the same side of the rail as the bond, and reducing the sectional diameter of the hole through terminal at its outer end. The steel pin then displaced the metal on the far side of the terminal and enlarged its external diameter, keeping it from falling out.

An endless number of bond terminals have been devised to effect a contact between a copper bond and a steel rail. But nearly all of their inventors did not consider the fact that the ratio of copper expansion under heat is greater than that of steel.

Therefore, if a cylinder of copper is compressed even with hydraulic pressure into a cylindrical hole in a steel rail and the metals heated, the copper must occupy greater cubical space than before.

It cannot expand in the direction of the steel walls surrounding it, therefore all of the expansion must take effect in a line parallel with the center of the cylinder, thus increasing its length while heated. When, however, the metals are allowed to cool the contraction takes place equally in all directions instead of entirely in one line as did the expansion. Therefore when the cooling is completed the copper cylinder is of less diameter than before. Into this small space moisture is sure to penetrate, forming an incompressible layer of iron oxide.

When the next heating takes place the same process is gone through and the copper is still further reduced in diameter. Finally, though the mechanical joint between the bond and the iron may seem perfect, the layer of iron oxide may be so thick as to practically ruin the conductivity of the bond. It is well known that in boiler or girder work, iron rust will inevitably form beneath the head of a steel rivet applied under hydraulic pressure in a steel plate with exactly the same coefficient of heat expansion.

But perfection of contact between copper and steel is not the only problem in rail bonding, since even with the best type of joints there will be some motion between the rail ends under passing cars and with difference in temperature. It was found that the solid wire bonds crystallized and broke between the terminals, therefore the solid wires were replaced by flexible copper strands with enlarged terminals cast or welded on the ends.

It was then found that stranded copper bonds with cast copper heads could be fastened more firmly to the rails by screw or hydraulic compression than could similar bonds which were applied by driving the conical pin. However, the great rigidity in the terminal had the effect of causing the strands to wear out the sooner. A similar effect was produced when copper bonds were welded to steel rails, with the additional disadvantage that welded steel and copper form a thermo-electric couple, and the loss due to the Peltier effect of current transmission was often far greater than the resistance loss.

Returning for a moment to the matter of contact between two metal surfaces, any one who has ever scraped a slide valve to a fit will appreciate the fact that metal plates, even when ground to a "true" surface, are nothing more than a series of high points surrounded by depressions which are clearly shown by the microscope. Realizing this fact and knowing the high resistance of iron oxide on contact metals, in 1894 an inventor hit upon the scheme of coating steel and copper contacts with an adherent layer of amalgam applied by an alkaline process. On this prepared surface a layer of a plastic metal was placed and as this filled all the inequalities of the contacts and prevented oxidation, currents could be transmitted at the rate of 1,500 amperes per square inch of section without contact loss. From this scheme was evolved the plastic rail bond in which a bit of plastic metal is used to bridge the space between rail and angle plate.

The metal putty is held in place by a case or ring of cork material, which is normally 50 per cent. thicker than the space between the rail and the plate; it is therefore compressed when the plate is bolted down, thus effectively sealing its contents. The plastic material adhered to the amalgamated surfaces and maintained a contact of low resistance for years in spite of the motion due to passing cars or temperature changes. The writer was one of the first to use this type of bond with satisfactory results both at the outset and after many years of use.

Bonds of this kind installed by the writer in 1895 showed in 1900 an average drop of ·001 volts, while a reading of the same length of unbroken rail section gave ·003 volts.

The following letter, dated August 21, 1903, has recently been brought to my notice, which shows even better results after seven years' service:

"In August, 1896, we received two plastic bonds as sample. I had our foreman, Mr. Hullin, place them on a 51-pound joint of Johnston girder rail. The bond had never been disturbed until a few days ago. I was at the time making some tests with a Conant bond tester. When I came to this joint I found the resistance was so much less than in the others that I determined to have it opened, so I could account for its low resistance. After opening it, I discovered that it was the joint with the plastic bond, which showed no more resistance than the rail itself. After having been under service nearly seven years, I found the alloy and contact of bond in perfect order.

(Signed) F. A. Ross, *Supt. Railway Dept.*,
Sacramento Electric, Gas and Railway Co."

To the average engineer this type of plastic bond does not appeal, since it does not seem mechanical, and it is evident that if the angle plate gets loose the material of the bond will be lost.

It is also evident that any other type of bond with loose angle plate will soon be destroyed.

The use of this bond and familiarity with the permanence of the plastic alloy contacts led the writer to design a bond composed of an amalgamated copper strip held in contact against the web of rail by screws threaded through the angle plate. One end of the strip was in contact with one rail, and the other end with the second rail. The thrust of the screws was received on a thin steel plate and both the copper plate and the web of the rail were amalgamated and covered with the plastic alloy. This type of bond has given entire satisfaction after many years of service.

A modification of this bond called the solid copper bond has had very extensive use in all parts of the world. In this bond the screws used by the writer were replaced by a pair of strong steel springs of the nut-lock type placed between the inner surface of angle plate and the amalgamated copper strip. The thrust of these springs is taken by a soft steel plate to prevent wearing holes in the copper of bond.

To keep grit and dirt away from the contact surfaces and to hold the springs in place before the bond is applied, the conductor strip is attached to a plate of cork material overlapping the ends and sides of the conductor. When the angle plate is bolted up, this cork plate is compressed so that it touches the web of the rail and the sides of the bond.

A plate of similar cork material is placed between the rail ends, thus sealing the crack which would otherwise admit dirt and let out the plastic covering of the bond. With this type of bond the motion of the rail ends under passing cars serves to improve the contact.

It is interesting to note that stranded bonds of the crown or horse-shoe type have much better conductivity and last far longer if their terminals and the holes in the rails are amalgamated and covered with a thin layer of the plastic alloy.

During the past few years the short-stranded copper bonds have broken to such an extent that few roads use less than seven inches between centers. With bonds of this length and the modern heavy rails and angle plates, mechanical breakage of the bonds has been greatly reduced. But careful tests show plainly their falling off in conductivity through corroding terminals.

Several different types of bond-testing apparatus have been designed in the past few years. One type is attached to a car which is drawn over the road, and its designer and proprietor is said to record the exact electrical condition of the bonds in a single round-trip at the rate of 6 or 8 miles per hour. This might be possible with accuracy if the rails were clean and bright. But with the ordinary conditions of track covered with dust and scale, this is impossible. Careful measurements with the milli-voltmeter will show very different results.

An ingenious type of telephonic tester has been designed by a Boston engineer, and seems to get the most rapid results with a fair degree of accuracy. But for absolute precision nothing can equal milli-voltmeter measurements of a given length of unbroken rail compared simultaneously with the same length including the bond. Even with this method, it is necessary to amalgamate the three contact spots for the instrument in order to obtain absolute accuracy.

A steel point forming a terminal of the milli-voltmeter will give results very often proportional with the amount of pressure applied or the number of scratches made in the same place on the rail.

The most serious side of this subject to an electric railway is the fact that every year the bonds are losing conductivity either from mechanical or chemical causes: breakage or corrosion.

It is now well known that poor bonds often double the amount of power required to operate a given number of cars.

That being the case, the accurate testing of rail bonds and the replacement of defective bonds is a subject whose importance cannot be over-estimated.

When defective bonds are found in a paved street or even on exposed track, it is a serious problem to apply a new bond without great expense. To use a flexibe copper bond under the angle plate requires the removal of a large amount of pavement and of the angle plates. This means the loss of fully 50 per cent. of the nuts and bolts, and after the bonding is completed it is almost impossible to replace the plates in the location previously occupied. However tight the nuts may be screwed up, the fins left by the former position of the plates will prevent a tight fit. After the pavement is replaced and a few months have gone by, these fins wear away and the plates get loose, and both joint and bond are soon in bad condition.

The flexible copper bond around the angle plate requires a greater amount of pavement removed, the bond is expensive, and when the pavement is replaced, it is easily broken off by the movement of the rail.

An ideal bond for this purpose is one which disturbs the least amount of pavement in placing, which can be applied without removing bolts and angle plates, and which will permit a reasonable amount of motion between the rail and plate. This idea is very well fulfilled in what is known as the Plastic Plug bond.

Two holes are drilled through one angle plate at each joint, so that the drill passes through the base or foot of angle plate and partly through the base of the rail. After this hole is drilled and amalgamated, a small amount of plastic alloy is placed in it and a T-shaped copper plug driven far enough to dip into the plastic alloy.

The top of this T makes an amalgamated contact with the angle plate; its bottom drops into the plastic alloy in the rail. The bond permits a motion between plate and rail of ¼ inch or more in every direction without breaking the electrical contact, and the bonds have great conductivity even after many years' use.

I should not advise the use of a smaller size than ¾ inch diameter for this type of bond, as the ⅝ inch size does not permit sufficient motion or expansion and contraction. The ⅞ inch size, wherever the rail will permit it, is still better.

A simpler form of this type of bond is made by drilling a hole parallel with the upper edge of the angle plate, so that half of the hole is in the lower edge of rail top, and the other half in the upper edge of angle plate. After this hole is drilled and amalgamated, a copper rod of cylindrical section is driven into it and held in place by burring the rail over top of the rod. As the rail moves on the plate this rod is partly sheared, but not enough is left of the copper unsheared to make the bond of very high conductivity.

Queerly enough, even if the motion be sufficient to entirely shear the bond, a hammer blow will force both parts into intimate contact and restore the full conductivity. One form of this bond splits in advance the copper cylinder so that the halves slide on each other as the motion takes place; but this does not seem to give as satisfactory results as the solid cylinder.

Of course one important point in favor of this type of bond is its cheapness. But whatever type of bond is used, frequent inspection and immediate replacement of defective bonds is of the utmost importance.

A SILVER-LIKE METAL.

A writer in the *Aluminum World* gives the constituents of a hard alloy which has been found very useful for the operating levers of certain machines. The spacing lever of a typewriter is constantly handled when in use, and if made of iron or steel and nickel-plated, even heavily, the plating soon wears off, leaving the metal underneath exposed to rust and corrosion, a condition which, of course, is not permissible. If the levers are made of brass the matter is not helped to any extent, as the plating wears off the same as iron or steel and leaves the brass exposed, which is, if anything, more objectionable than iron or steel. The metal now generally used for this purpose by the various typewriter companies is "aluminum silver," or "silver metal." The proportions are given as follows:

Copper	57.00
Nickel	20.00
Zinc	20.00
Aluminum	3.00
	100.00

This alloy when used on typewriting machines is nickel-plated for the sake of the first appearance, but so far as corrosion is concerned, nickeling is unnecessary. In regard to its other qualities, they are of a character that recommends the alloy for many purposes. It is stiff and strong and cannot be bent to any extent without breaking, especially if the percentage of aluminum is increased to 3.5 per cent.; it casts free from pinholes and blowholes; the liquid metal completely fills the mold, giving sharp, clean castings, true to pattern; its cost is not greater than brass; its color is silver white; and its hardness makes it susceptible of a high polish.

NATURAL BORAX.

The mineral borocalcite furnishes the base of the greater part of the borax consumed in Europe. Fifteen parts of finely crushed ore with 60 parts water, 8 parts sodium bicarbonate and 2 of caustic soda are boiled in a steam-heated boiler about three hours. It is then filtered and crystallized, yielding crystals of borax. It is estimated that 100 pounds of borocalcite will yield from 100 to 105 pounds of crystallized borax.—*Engineering and Mining Journal.*

Mining and Metallurgical Section.

Stated Meeting, held Thursday, January 30, 1904.

The Petrified Forests and Painted Desert of Arizona.

By Prof. Oscar C. S. Carter.

The physiographic division of Arizona is extremely simple and well marked. There is a high plateau in the northern half of the State and a low desert area in the south; a high wall or escarpment separates them. This escarpment enters Arizona from Utah on the north and trends from the northwest to the southeast; it is really the southern border or end of the great Colorado Plateau, which includes parts of Utah, Arizona and New Mexico, and extends from Utah southward, often as a series of gigantic steps. It is called the Colorado Plateau on account of the river of that name, which has cut in the plateau the most stupendous gorge in the world—"The Grand Cañon of the Colorado." Portions of this plateau are more than a mile higher than the desert area in the southern part of the State, and, as Merriam has pointed out, it acts as a barrier to the passage of animals and plants, but it must not be supposed that the boundary is always a cliff.

In this northern plateau in Arizona there is a vast depression or basin called the Painted Desert, which is the drainage area of the Colorado Chiquito or Little Colorado, which empties into the Colorado. The corrosion of the stream and its tributaries, which are often dry, and all the other forces of erosion have cut this basin and its channel and widened it. From near the mouth of the Little Colorado this Painted Desert extends southeasterly for a distance of 200 miles, and even enters the border of New Mexico. In its widest part, near the middle, the desert is about 75 miles wide. The slope, of course, is toward the Colorado River. It is called the Painted Desert on account of the bright colors of the sandstones, shales and clays.

Mesas of bright red sandstone are common. The shales are eroded into bizarre and fantastic shapes; all of these forms of erosion are colored, blue, yellow, red or green as the case may be, and with the bright sunlight and clear, dry air, the coloring is often brilliant. The Petrified For-

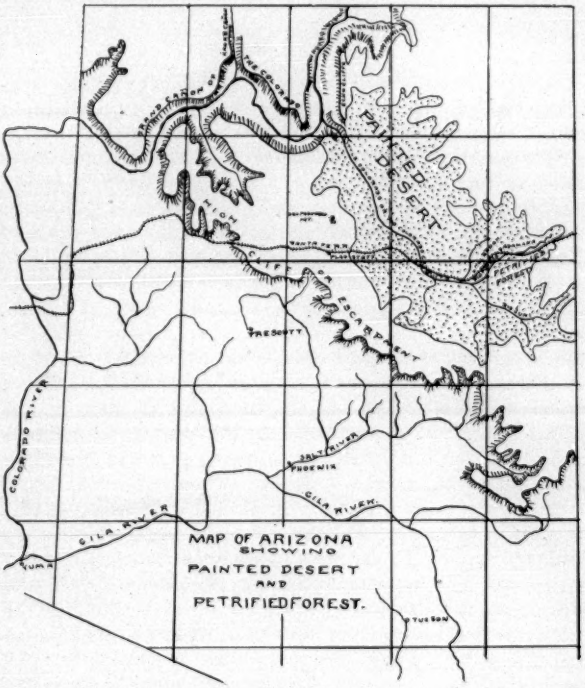


FIG. 1.

est is near the southern border of the Painted Desert, between the Rio Puerco and Zuni River, which are tributaries of the Little Colorado. The Painted Desert is not much of a basin or depression in this southern part of its area, as the

average elevation is over 5,000 feet above tide; neither has it any connection whatever with the low desert area in the southern part of the State. It is wholly in the plateau country. The Petrified Forests of Arizona may be classed among the strange corners of our country, and lie more or less off the beaten track. The general public do not as yet visit this locality as they do the Yellowstone or the Yosemite, yet it is quite accessible. More than 3,000 people visit the Yellowstone annually, and the number is increasing, yet Adam Hanna informed me, in 1889, that he had about a dozen visitors annually to his ranch on the Painted Desert, which is the nearest place to the Petrified Forest.

Thousands of visitors at the World's Fair became interested in the Petrified Forest when they admired the logs and polished slabs of petrified wood of various colors, bright red predominating. Sometimes they are cut into table-tops and pedestals. Very few, however, had any idea as to how the forest may be reached. The Mormon town of Holbrook is always associated with the Petrified Forest, probably because it is the only town of any size near the forest, except the still smaller station of Carrizo, which can be reached by a drive of 20 miles or more. If we take a folder of the Santa Fe Railroad we will see a flag station named Adamana, which is the best place to reach the forest. It is simply a signboard or mile post marked 233 Adamana, and is near the southern border of the Painted Desert, although the desert does not have the rich colors which the shales give it farther north. The forest is found scattered over from 8 to 10 square miles of territory, principally in township 17. Adamana is about 21 miles east of Holbrook. The conductor will have no compunction about dumping you down in the desert among the sage and soapweed, providing you keep on the alert and remind him not to run past the mile post. When the train rushes by you can see Adam Hanna's ranch in the distance, from which the station takes its name. The river fringed with cottonwoods (Populus monilifera), known as the Rio Puerco, or dirty river, runs lazily past the ranch. It is well named dirty, for it is always the consistency and color of strong chocolate. It is so muddy that no living creature is found in its waters.

FIG. 2.—View of a part of the Petrified Forest.

FIG. 3.—Agate bridge, 111 feet long, spanning ravine between mesas.

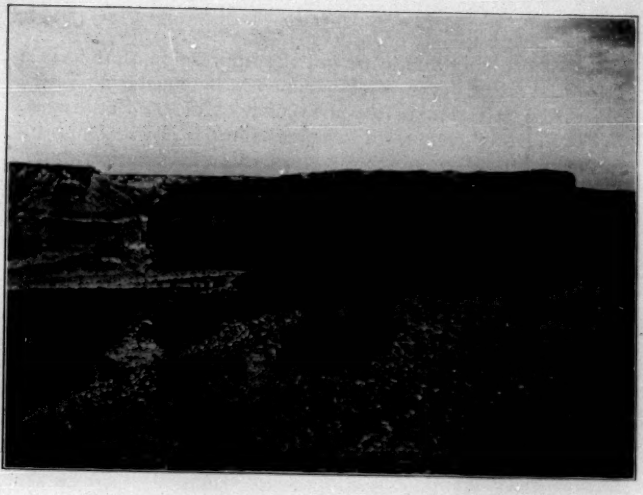


FIG 4.—Agate log called the cannon, on top of the mesa.

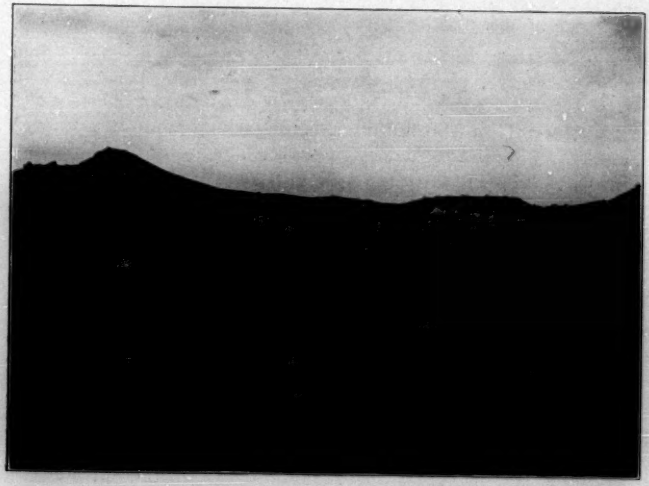


FIG. 5.—Differential weathering of sandstone and shale in Petrified Forest.

On consulting a map we get the impression that it is a fair-sized river, but it is a river merely by courtesy. There are no large rivers in the arid district of the Southwest. What they call rivers, we call creeks in the East. The rainfall is slight, only 10 inches a year, often less, and evaporation so rapid that the air takes up the water like a sponge; hence, large rivers are out of the question, and some of them even disappear entirely under the summer's torrid sun. In a country like this they don't need to hang up clothes to dry, they will dry quickly enough on your back should you take a bath impromptu. Even the perspiration which comes so freely in traveling over the desert is soon dissipated by the hot dry air. It is no unusual sight, in the desert region farther north, to see a copious shower of rain falling from the clouds above, which never reaches the parched and dry shales of the desert because the hot dry air above the desert evaporates and absorbs it so quickly that it soon disappears. Even when a cloudburst occurs and the rain comes down in sheets, which is a common occurrence in the rainy season in July and August, and the arroyos are full of turbid streams of often liquid mud several feet in depth, yet in a few hours the desert is as dry as punk, and there is no evidence of a shower except the alkaline water which stands for a short time in the mud-bottomed pools. The Rio Puerco, in the summer, is not wider than a country creek and can be forded by the horses, but after cloudbursts in the higher plateau country, a stream of liquid mud 10 feet deep spreads from the mesa to the Santa Fe road, and even comes to the door of Adam Hanna's ranch. Fording the stream, however, is not child's play unless you know the ground, because the horses become mired and sink to their middle.

As Adamana is the nearest and best place to reach the forest, and Adam's ranch is the only one for miles at which the tourist can stop, our host deserves perhaps more than a passing notice. His life since boyhood has been spent in the Southwest, and has been a checkered one. He has been sheriff, herder, scout and section boss. Adam drove the stage between Denver and Salt Lake City in the early days

when it was a perilous undertaking; an Indian arrow wound in the leg testifies to his worst experience. He was also sheriff of San Juan County, Colo., and was located at Silverton, where the desperadoes made their headquarters when driven from Leadville. He was scout for General Buford for a while, and recently served two terms as sheriff of Apache County, Ariz., where he now lives. The office of sheriff in parts of Colorado and Arizona was not always a sinecure, and his reminiscences are sometimes entertaining. Adam took government claim of 160 acres and built his ranch alone in 1884. He had between 250 and 300 horses scattered over the near country, as well as many cattle. He drives cattle from Mexico to Deeming, Colo., where they are sold. When on these long journeys his wife stays alone on the ranch and plays the part of hostess.

There are no neighbors for miles. Two road-agents, who held up the Santa Fe train successfully, took supper there, but she did not know who they were until afterward. There is certainly a charm about the desert with all its disadvantages. The sunsets are beyond description. No matter how hot it is during the day, the nights are always cool. In that rare and dry atmosphere radiation is rapid, and the earth cools so rapidly that out of doors a blanket is comfortable at night. Cool nights on the desert are the rule much further south also, and in the report of the Mexican Boundary Commission, Capt. D. D. Gaillard reports temperatures of 110° F. and 115° F. in the shade, and even higher temperatures were recorded by standard thermometers; yet in the evening the temperature would drop to 65° F., a range of 50° during the day. Unfortunately it was not the shade temperatures with which the commission had to contend in traveling across the desert. The traveling was done in the open, and the low leafless flora of the desert are useless for shelter. Even the Giant Cactus (*Cereus giganteus*), which attains a height of from 40 to 50 feet, and the large and striking cactus called pitahaya by the Mexicans, which were passed by the commission near the Mexican boundary line, afford no shelter worthy of the name. At the Petrified Forest and to the north in the

FIG. 6.—Agate logs, from 15 to 20 feet in circumference.

FIG 7.—A stranded log *in situ* on an eroded ledge of sandstone, once embedded in that rock.

FIG. 8.—Enormous logs stranded on shale along the slope of the mesa.

FIG. 9.—A log *in situ* embedded in sandstone.

higher plateau country the nights are so clear that one can almost read a newspaper; Percival Lowell took advantage of this fact when he located his observatory at Flagstaff, Ariz., where some most important work has been done mapping out the canals of Mars, which has attracted attention at home and abroad. Work of this character could not be done in a smoky and hazy atmosphere like the East. At Adam's ranch the coyotes come close to the house for water from the pond; the Rio Puerco is too muddy. One can hear their peculiar bark at almost any hour of the night. The fauna and flora of the desert here are of a source of interest. Bright-colored lizards dart across the sand and an occasional horned toad seems clumsy when its movements are compared to the lightning darts of the lizards. The jackass rabbits which one starts from every clump of bushes are making sad havoc with Adam's little patch of Kaffir corn, the only crop he irrigates. Birds are scarce; the burrowing owl and desert sparrow are there, and Hanna says that one hears the mocking bird and oriole among the cottonwoods that fringe the Rio Puerco. Mrs. Hanna recently moved away from a wild cat among the branches directly overhead. Adam and a cowboy drove one from the cottonwoods and lassoed him in the open.

Small nocturnal forms of desert rats and mice and bats are met with. The sage (*Artemesia*), Mexican grease-wood (*Atriplex canescans*), soapweed, cacti and yuccas is the flora, with here and there a blade of grass struggling through the sand, scarcely enough for the cattle and horses when there is little rain. Those who have taken the trip to the Grand Cañon in the higher part of the plateau to the north during the rainy season of July and August have noticed how the open pine forests and vicincity are often carpeted with wild flowers, which soon gain a foothold after the rains. Some of these wild flowers are occasionally seen on the desert during the rainy season, but they do not last long.

An interesting fact about subterranean water for irrigation is that abundance of pure soft water is reached at a depth of less than 50 feet on Adam's ranch. The underground water of the Southwest is often hard, Adamana is

an exception. A windmill on the ranch supplies an enormous pond, more than 100 feet in diameter and 4 feet deep, with a plentiful supply sufficient for irrigation. The soil is fertile enough, and with irrigation fruits and vegetables of all kinds suitable to the climate could be raised. Under the present administration irrigation is receiving a fresh impetus, which will work wonders where irrigation is possible and reclaim much worthless land for the settlers. It has been

FIG. 10.—Pictographs made by cliff dwellers on sandstone, near Petrified Forest.

estimated by some that the arid land that can be reclaimed amounts to from 70,000,000 to 100,000,000 acres, an area larger than the New England States, New York and Pennsylvania combined; but it must not be forgotten that a greater part of the arid region can never be irrigated at all on account of elevation, absence of water above and underground, and other causes.

In some parts of the United States 25 acres of watershed

are required to collect enough water to irrigate an acre of ground. This helps to realize this fact. I stopped once at a little station called Humboldt, in Nevada, the surrounding desert was desolate and bare of trees; but I was surprised to find a grove of cottonwoods and a bright green sward in the struggling town, while a little fountain played at the station. It was a veritable oasis in the desert. A crowd of loungers, when questioned as to the source of the water

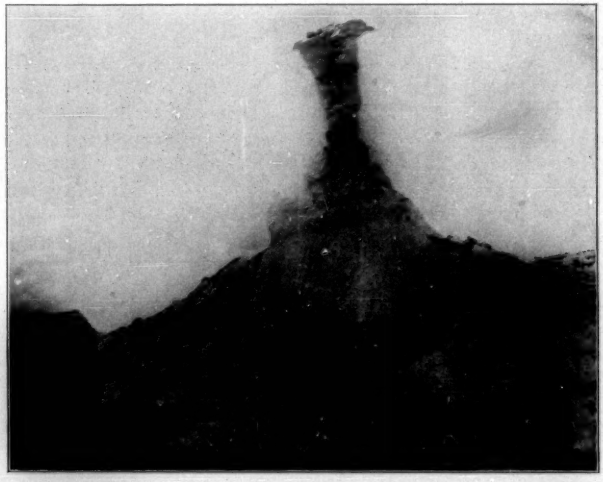


FIG. 11.—The Eagle's Beak. A freak of erosion of sandstone and shale.

supply, said it was piped a long distance from the mountains. They were asked, "Why not sink artesian wells?" Whereupon the spokesman said it reminded him of a question he once asked in a Kansas town. He asked a native where they obtained so much water and was informed that they piped it 7 miles from the hills. "Why don't you put down artesian wells?" he asked. "Distance just the same," replied the man.

The trip to the Petrified Forest is best made in the cool

hours of early morning. After fording the Rio Puerco, where the horses sink to their knees in mud, we soon strike the trail, and after an hour's journey we reach the mesas. These mesas rise to 60 or 70 feet above the desert. They are made up of a white disintegrating sandstone rock, which is held together by a feldspathic cement. Between the layers of sandstone are layers of red shale colored by red oxide of iron. It is at the base of and between these mesas that the petrified trees are found. The first indication of petrifaction one sees is bright red and yellow pieces of agate and chalcedony, showing the outlines of the bark; these are scattered over the ground long before one reaches the mesa, but no logs or large pieces are met with yet. After reaching the mesa we are strongly tempted to collect specimens, which would be considered fine enough to grace any mineral cabinet in the East, but Adam cautions us to wait, as there are more beautiful specimens farther on. Suddenly the horses make a turn around the edge of the mesa and then we see scattered over many acres enormous logs completely changed to agate, jasper or chalcedony. The sections or ends of the logs show brilliant reds, yellows and dull blues. The bark is not brilliant but dull and wonderfully well preserved, being almost lifelike in its naturalness. Some trees show even the knots to perfection; but even these trees, spread over many acres, are not the finest.

After a short drive between the mesas and another turn we come to some enormous logs. These are 4 feet in thickness and from 10 to 12 feet long. They have no branches, but the hundreds of small pieces, varying from a couple of inches to 1 foot in diameter, are probably in some cases the remains of branches. After a drive of several miles along the base and on top of the mesa through many hundreds of petrified trees, we failed to see a tree with branches or even one standing upright. All of the trees were lying on one side. Another important fact is that no tree, except one, was found which showed the entire length. There were many logs from 3 to 30 feet long. The one exception to this was well worth a visit. After clambering across the mesa we come to a ravine 50 feet in depth in the deepest part.

In the bottom are growing a clump of cedars, the only trees about the mesa. Spanning this ravine, which is 44 feet wide, is an enormous petrified tree which measured 4 feet in diameter in the thickest part. The tree does not end on the edge of the chasm, but continues across the sandstone mesa and enters a ledge of sandstone, making the length of the tree that is visible 111 feet. How far it extends into the sandstone we cannot tell. This is the only perfect tree we saw. It is interesting to account for the preservation of this entire tree and also to account for the fact that logs instead of trees are the rule.

It is the writer's opinion that some of these trees were broken into logs after they were petrified, and while they were imbedded in the solid rock. The entire plateau country comprising New Mexico, Arizona and beyond, were elevated in recent geological times (Tertiary) from 4,000 to 8,000 feet above tide. This elevation was gradual, but the strata, nevertheless, were subjected to pressure and enormous strain, which fissured them and cracked the trees while they were still imbedded in the sandstone and shale, before they were loosened by erosion. This seems more reasonable than the statement that they were split into sections by heat and cold, although, doubtless, many were. This large tree spanning the ravine has been called the natural bridge of agate. Unfortunately, there are several transverse cracks in this tree, and one near the mesa seems to extend entirely through the tree, making the position insecure. This is shown in the photograph. It should be braced in some way so as to prevent the entire collapse of the tree into the ravine below, as it will always be a source of wonder and interest to tourists, when the area is set aside as a Government Park, which will probably be done, as the bill has already passed the House. It may be that these trees are not *in situ*, but floated there in past geological ages, perhaps, down an ancient river into an inland sea, where they were buried in the sand and mud near the shore after they became waterlogged. These layers of mud and sand became shale and sandstone in after years, when the sea receded or evaporated owing to a change in climate

and other causes. The fact that shifting currents were active is readily proved. Photographs of sandstone showing cross bedding to a marked degree were obtained. It may be, however, that these trees grew along a shore line that was afterwards submerged, and they became buried in sand and mud. They are much crowded and the former view may be the correct one, although we cannot prove it.

How do we account for the fact that these trees are found stranded at the base and on the top of mesas? This is very simple. These mesas were once a continuous plateau of sandstone and shale, when a break, crevice or line of weakness once began, erosion soon completed the work and the gaps widened until finally the plateau was dissected into a series of mesas. As the disintegration of the sandstone and shale proceeded, the trees imbedded in the rock would be loosened and finally roll down to the foot of the mesa, where the most of them are now found. As these strata are of mesozoic age, many layers of rock must have disappeared since that time by erosion, so that the trees at the foot of the mesas and in the arroyos are not in place, but came from a higher horizon of sandstone which has disappeared by erosion. There are, however, many trees in place imbedded in the solid sandstone rock, their branches and trunks projecting from the edges of the mesas and plateaus; but most of these trees in place are in the highest part of the forest at an elevation of 5,700 feet above tide; these trees in place are several hundred feet above the valleys and arroyos in which the loose stranded trees are found. The Natural Bridge is the largest tree in place, and most of the trees in place are found in a coarse-grained sandstone, with a feldspathic cement; the cross bedding indicates shifting currents. While examining one of these trees, a lizard of brightest green darted under a rock. It seemed to be about 8 inches long and the scales fairly glistened in the sun. That layers of sandstone of immense thickness have disappeared from the top of the mesas one can readily see at a glance, because some of the trees are loose on top of the mesas where they were deposited when the rock eroded away. All of the trees have been changed to some form of

quartz, either agate, chalcedony, jasper or opal. By far the greatest number have been changed to the varieties of silica which have a waxy lustre. It is a well known fact that quartz resists erosion of all kinds better than any other mineral. It is practically insoluble in mineral acids and also in cold water. The only solvent met with in nature besides some organic acids, from decaying wood and vegetable matter, is hot water containing the alkalies, potash and soda in solution. So we may consider quartz one of the most insoluble minerals known. When granite rocks are exposed to the action of waves along the shore line, parts of all the minerals of the rock dissolve in the course of time except the quartz, and that forms the beach sands. Along the Atlantic Coastal Plain are quartz sands, and this would not be the case were it soluble and easily eroded. We can understand from this then, why petrified trees have resisted erosion and lasted so many ages, while the sandstone and shale in which they were imbedded have disintegrated and been swept away. Sandstone is simply made up of grains of sand held together by some cement. It may be clay, iron oxide, feldspar or lime carbonate. If the cement be slightly soluble the grains of sand are soon loosened and the rock disintegrates and is washed away.

We can easily see from this how the mesa in which the trees were imbedded has eroded, while the trees rolled down to the base of the mesa or were left stranded on top. Several peculiar mounds of rather striking appearance were noticed on the desert near the mesa, not far from the trees. These have been pronounced by some, after superficial examination, to be extinct geyser cones. There is no evidence whatever to support such a statement. The mounds are simply mounds of disintegrated colored shale, the peculiar form being due to weathering; no indication of geyserite was found. The mounds are certain to attract attention. They are due to erosion, because some mound-like forms were seen capped with a pinnacle of harder resisting sandstone. As soon as this topples over and disintegrates and is washed away by rains, then the underlying and softer shale will be moundlike in form. One of the most interest-

ing and bizarre forms due to erosion, which surpasses many unique forms in the Garden of the Gods, is the so-called Eagle's Peak.

This is a mound of peculiar shape at the base, surmounted by a shaft about 25 feet high, on top of which was a slab; both shaft and slab are of sandstone. When erosion proceeds far enough and the peak topples over, one of those peculiar mounds will be formed. The geological horizon to which the sandstone and shale of the forest belong is in dispute. J. W. Powell, formerly director of the U. S. Geological Survey, claims to regard them as Jurassic, while the other evidence seems to point to Cretaceous age. They occur probaby in the Shinarump group of Powell. Sections of this wood under the microscope show that it is conifer. In 1853 Mollhausen discovered a petrified forest in a ravine near the Little Colorado in Arizona. The wood was submitted to Dr. Goppert, who pronounced it a conifer belonging to the Abitineæ. The Rio Puerco is a tributary of the Little Colorado. One of the logs in front of the U. S. Museum at Washington was taken from the mesa 2 miles north of Fort Wingate, N. M., which is not far from the Rio Puerco and just over the Arizona line. They were studied by F. H. Knowlton, who states that they are the same as Goppert's Araucarites Mollhausianus. Not Araucarites as that genus is understood, but Araucarioxylon Arizonicum from the fact that most of the wood is found in Arizona. F. Kunz, who visited a part of the forest near Carrizo, Ari., states, in the *Popular Science*, that he found trees projecting from volcanic ash and lava, which are covered with a depth of sandstone from 20 to 30 feet. He says the trees lie in gulches where the water has worn away the sandstone and the trees were overthrown and covered with a volcanic ash and tufa.

Dr. P. A. Dudley, of New York, examined this wood and says it belongs to the genus Araucaria, and that Araucaria excelsa, the present Norfolk Island pine of the South Pacific, grows to a height of 150 to 200 feet. Other pieces, he says, resemble red cedar Juniperus Virginianus. Be this as it may, many specimens show that the wood was going to

decay before it was petrified. The writer was not able to find any trees imbedded in lava of any kind; all the trees in place were imbedded in sandstone. The paleobotanist, Lester Ward, states that all the imbedded trees he examined were in sandstone. Scattered over the desert, way beyond the mesa, the writer found isolated pieces of lava, very small. Cinder showers and volcanic ash were common in Arizona in past ages, and lava flows are so common in the plateau country that one can pitch his tent almost every night on a lava flow, but most of the flows took place in tertiary times and many are more recent still, as their fresh surfaces little worn by erosion indicate. The trees are of mesozoic age, so that these trees were petrified long ages before the most of the lava flows took place. The writer believes that most of the petrification took place in the sandstone and shale, and was due to soluble silicates derived from decomposition of feldspar, which is the cement binding the sandstone. The silicate of potash or soda produced the petrification when it came in contact with the vegetable matter or trees that were imbedded. The silicates are soluble in rain water, and as they percolate through or over imbedded woody material the organic acids derived from the decomposition of the wood will decompose the silicate of potash and set free silica in the amorphous or gelatinous form, which will be precipitated on the wood and in the pores until the substitution is complete. In Pennsylvania pieces of petrified wood are found in new red sandstone; a feldspathic cement binds the grains of sand. We find petrified wood in many other localities far removed from lava.

Near Adam's ranch a small plant was erected by a Denver company, who intended to crush the agate trees and use the powder for an abrasive agent as a substitute for emery. The plant was never started, probably because of the introduction of a harder abrasive called carborundum, made in the electric furnace from coal and sand. At Sioux Falls, Dak., they polish petrified wood and make magnificent table tops and pedestals.

In the Yellowstone Park (U. S. Geological Survey Mono-

graph XXXII, Part 2) are found many petrified trees, but they are standing upright. They do not rise to any great height. They are mostly trunks on the slopes of mountains, and the highest of them rise to only 20 or 30 feet. They are found near Lamar River, the finest exhibit being on Amethyst Mount and Specimen Ridge, near the road between Mammoth Hot Springs and the town of Cooke, Mon. Yancey's fossil forest is one mile south of his hotel, on the slope of a hill 1,000 feet above the valley. There are only two trees of considerable size, the largest stump being 15 feet high and 13 feet in circumference. The bark is not preserved, so that the true diameter cannot be ascertained. They belong to the genus Cupressoxylon. Some trunks rise only a few inches above the ground. Some of the trunks near Specimen Ridge are sequoias. In early tertiary times these forests were supposed to have been buried under debris ejected from volcanoes and afterwards surrounded with water charged with silica, which petrified them. The largest trunk in the park is 10 feet in diameter. These trees which grew in tertiary times cannot, of course, be compared in age with the trees of the Petrified Forest, Arizona, which grew in mesozoic times.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, January 30, 1904.

Correspondence.

SOME FURTHER NOTES ON CAST IRON.

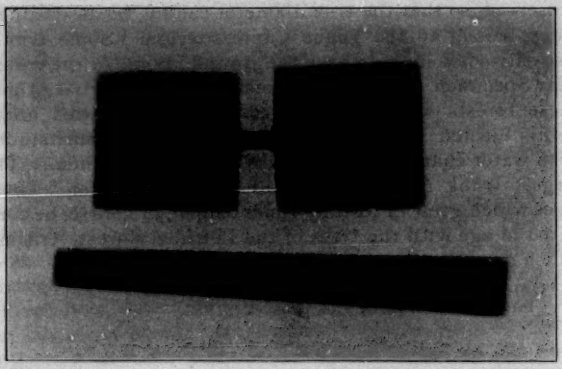
To the Committee on Publications:

(1) Noticing the comments of Dr. Goldsmith (entitled "Does Cast Iron Grow?") in your current issue, I would say that I think it highly probable that the pressure caused by expansion of occluded gases in cast iron plays a prominent part in the phenomena noted in my paper on "Recent Investigations and Discoveries in Cast Iron," printed in the *Journal of the Franklin Institute*, February, 1904. I believe, however, that these gases ultimately escaped through the pores of the metal which has been expanded by repeated heating and cooling, and the intermolecular spaces are now filled with air.

In a paper entitled "The Mobility of Molecules of Cast Iron," read before the American Institute of Mining Engineers, at its recent meeting at Atlantic City, I stated my reasons for this belief, and in the original address

given at the Franklin Institute, I performed an experiment to prove this, the account of which I omitted to incorporate in the printed paper referred to by Dr. Goldsmith.

The experiment was as follows: A small tank filled with water was placed in the lantern and its image thrown on the screen. A section, ¼ inch thick, of a cast-iron test bar before being expanded by heating, and a section, of the same thickness, cut from the same bar, after having been expanded 30 per cent. in volume, both placed in the tank, side by side, showed a surprising difference in behavior. It was observed that bubbles of gas were forced out from the entire surface of the expanded metal by the pressure of the water, while no such action took place on the surface of the untreated metal. I stated that the piece had been immersed in water several times, and the first time it gained 870 milligrams in weight, due to the absorption of water. When



Radiograph made with radium of 10,000 activity (Curie's scale), showing remarkable permeability of cast iron, both expanded and untreated.

the piece is allowed to remain in a warm room for several hours after removal from the water, the water evaporates and air again enters to fill the void; this may be repeated many times.

The metal does not appear porous to the naked eye, but photo-micrographs show very clearly innumerable spaces or cracks, permitting the escape of occluded gases and ingress of water or air, as the case may be.

(2) Quite recently Messrs. Williams, Brown and Earle, of this city, have made some interesting shadowgraphs, or radiographs, for me by the aid of radium-bromide of high activity, imported from Paris, showing that emanations from this wonderful element discovered by Professor and Madam Curie, will penetrate cast-iron readily. In the half-tone illustration two pieces of the same cast-iron test bar, already alluded to in this communication, were cut to the same thickness, viz., $\frac{1}{8}$-inch, one before and the other after expansion.

These were laid upon a strip of lead (a metal which is almost impermeable to the emanations from radium) cut to a sort of dumb-bell shape. A tube containing 100 milligrams of radium of 10,000 activity (by the Curie scale), was placed centrally by measurement, 4 inches, above the pieces of cast-iron.

A wedge-shaped piece of steel, of the same thickness, was placed close to the cast-iron pieces, for comparison, steel being less permeable to these emanations than cast iron. After an exposure of thirty-eight hours the negative, which was placed beneath those objects, was developed and the print made therefrom.

Several curious and interesting phenomena may be noticed, *e.g.*, the rays passed through both pieces of cast iron, and were intercepted by the lead strip, making a distinct image of the lead strip underneath the cast iron.

The central portion of the lead exposed to the rays between the two pieces of cast iron appears narrower than the portion seen through the cast iron, and looks more like a round rod than a flat strip. Also, penumbra show around the edges of the cast iron and steel, indicating that the rays are in some degree deflected around the edges.

The fact that such dense metals as iron and steel are permeable to emanations from radium is very interesting, and may prove of practical value in detecting flaws. I am informed that the "X rays" will not penetrate these metals.

(3) Since my paper on recent investigations and discoveries in cast iron was read before the Mining and Metallurgical Section of this Institute, a disastrous fire has occurred at Baltimore, which has incidentally furnished convincing evidence of the great importance and practical value of a thorough understanding of the laws governing the behavior of cast iron and steel when subjected to high temperatures.

The following extract from a letter which I received from an officer of the Land Title and Trust Company, of this city, dated February 9, 1904, will prove this: "The chief engineer of the Land Title Building, who went to Baltimore to inspect the effect of the conflagration upon the Continental Trust Company's 16-story building, tells me that while the entire inflammable contents of that building were "roasted" and consumed, the steel framework is apparently plumb and intact. He also says that the cast-iron framework of the doors (which was set in granite) has expanded to a considerable extent, and has not again contracted. He says this permanent expansion is very noticeable."

I have reason to believe that if the framework of the doors and windows of this "modern fire-proof sky-scraper building" had been of light-steel construction, instead of cast-iron, and the doors sheathed with thin sheets of steel, or made of non-combustible material, the valuable contents of the building might have been saved from complete destruction by fire.

At all events, it may be assumed that if the facts given in my paper had been generally known and understood by architects and constructing engineers, the framework of the doors and windows of the modern steel skeleton buildings would not have been made of so unsuitable a material as cast iron, and I anticipate that in future constructions of this character these errors will be avoided in view of our present knowledge and recent experience.

Engineering News, of February 18th, prints an extended paper on the

effects of the Baltimore fire on so-called fire-proof structures. It says: "One of the most surprising effects of the fire was the noticeable extent to which cast iron had suffered permanent bends. This effect was most noticeable in the case of iron mullions of the tall office-building windows. These in many cases were bent several inches from a straight line, and in some cases these bends were veritable 'buckles' of the metal."

The writer of this account, like most other observers, noticed the "buckling" and "bending," but was, apparently, unaware of the fact that all of these cast-iron bars and frames had grown in cubic dimensions, and that it is this permanent growth which practically destroys the further usefulness of cast iron for such purpose after having been subjected to heat.

I regard the effects of the fire on cast iron in tall office buildings as a timely and valuable proof of the need of correct knowledge of these phenomena, which I have been studying for years, and have recently described in *The Journal of the Franklin Institute.*

ALEX. E. OUTERBRIDGE, JR.

PHILADELPHIA, March 8, 1904.

Notes and Comments.

STILL ANOTHER RADIUM PUZZLE.

What is becoming of our science of chemistry? Our century-old atomic conceptions have received a rude shock; the law of the conservation of energy, to which everything in this universe was supposed to be subservient, is attacked; and now we seem to be reverting to the dream of the medieval alchemist—actually thinking of the transmutation of metals.

This, at least, is what we have come to, after the announcement made by Sir William Ramsay that radium apparently changes to helium. When he compares the resultant product of radium with helium, Sir William Ramsay is sure of his ground; for in conjunction with Lord Rayleigh he carried on a series of classic experiments which ended in the discovery of argon and helium—a discovery which deserves to be considered one of the most noteworthy achievements in chemical physics of the nineteenth century. Sir William Ramsay caught the heavy gas which radium emanates, a gas so evanescent that it disappears after a time; he found that gradually its spectrum, entirely different from any hitherto recorded, displayed the characteristic yellow line of helium. Day by day the helium line grew brighter. In a word, one element seemed to have changed to another. It is quite necessary to know how fast radium is turned into helium. As yet little that is definite has been furnished. If nothing else occurs but the changing of radium into helium, then, Professor Ramsay figures, it will take 2,000,000 years to dissolve the gas.

Are we not perhaps on the verge of some great generalization, which will ultimately prove that just as we have many kinds of forces, all manifestations of one great force, so we may have seventy-odd elements, hitherto regarded as simple forms of matter distinct from each other, but in reality mere manifestations of but one matter? This strange, newly-discovered phenomenon

certainly tends to show that one element may be changed into another. "What is this?" asked Sir William Ramsay, "but an actual case of that transmutation of one element into another in which the ancient alchemists believed when they painfully sought to change lead into gold and incidentally founded the modern science of chemistry?"

Clearly, there are more things between heaven and earth than are dreamed of in our chemical philosophy.—*Scientific American.*

UTILIZATION OF BLAST FURNACE GASES.

For many years the fact has been realized that the blast furnace is practically a huge gas producer, and partial utilization of the fuel formerly wasted has been extensively practised in Great Britain and in other countries. More recently considerable progress has been made in utilizing blast-furnace gases by means of the internal combustion engine. As Mr. Humphreys showed in a recent paper, there were in operation at the end of the year 1902 fully 327 gas engines capable of developing an aggregate of more than 180,000 horse-power, and at the present time it is probable that the engines already built or in course of construction represent a total of some 220,000 to 230,000 horse-power, most of these engines being operated or intended to operate with furnace gas. In iron and steel works the waste gas is chiefly used for firing boilers supplying steam to steel plant, rolling mills and other machinery. The fact is now recognized that this is a roundabout method, and there is reason for believing that the continued improvement of large gas engines will ultimately render the use of steam unnecessary in large iron works. As an indication of movement in this direction we may mention the fact that the Buffalo works of the Lackawanna Steel Company are now being equipped with three new plants, one including eight 1,000 horse-power gas engines for driving dynamos, and two others having sixteen 2,000 horse-power engines for driving blowing engines.—*Scientific American Supplement.*

WASTE OF POWER.

The greatest waste of power in this country is found in the Connellsville coke region in Pennsylvania, where the gases from thousands of coke ovens pass off into the air. These gases might be used to operate gas engines and generate electric power, for which a market could be found in the busy districts, within an easy radius of transmission from the ovens.

STONEHENGE OFFERED TO THE ENGLISH GOVERNMENT.

Sir Edmund Antrobus has, through Lord Edmund Fitzmaurice, chairman of the County Council of Wiltshire, made a definite offer to sell Stonehenge and eight acres of land occupied by these magnificent Druidic ruins to the English Government for $250,000, on the understanding that they will be preserved for the nation. Some years ago Sir Edmund made an offer to dispose of Stonehenge and twenty acres of the land on which the great stones stand

for $750,000 to any one who was willing to pay that price, and great alarm was expressed lest some American multi-millionaire might purchase the celebrated megalithic monuments and carry them off to the United States. But this fear has not been realized. Sir Edmund's desire to get rid of Stonehenge is in no small measure due to the annoyance to which he has been subjected in the last few years in connection therewith. It was shortly after his accession to the baronetcy and estates on the death of his father in 1899 that he determined to surround Stonehenge, which forms part of his property, with a barbed-wire fence, and to charge an admission fee of 25 cents, his object being to protect the stones from the injurious treatment to which they were being subjected by people without any reverence for the hoary past. Moreover, as some of the stones were in danger of falling, he feared that in the event of anybody being injured thereby he might be held financially responsible. Exception, however, was taken to his attitude. It was said that inasmuch as Stonehenge had lain open to all the world since English history began, the public had acquired a right-of-way through every portion of the grounds on which the stones stood, and likewise a proprietary interest in the stones themselves. Then, too, it was pointed out that anything in the shape of a modern inclosure destroyed the spell created by the aspect of those immense stones standing alone in strange circles far from human habitation in the midst of a vast, open, rolling plain. And the result was that not only the general public, but likewise men of culture interested in the preservation of national monuments, raised a fund with the object of testing in the courts not Sir Edmund's proprietorship of the ruins, but his right to inclose them with a wire fence.—*Marquise de Fontenoy in New York Tribune.*

HEIGHT OF THE SEA BREEZE.

Observations as to the height of the diurnal sea breeze are few in number, albeit of considerable importance. By means of a captive balloon, sent up from Coney Island a number of years ago, it was found that the average height at which the cool inflow from the ocean was replaced by the upper warm outflow from the land was from 500 to 600 feet. At Toulon, in 1893, the height of the sea breeze was found to be about 1,300 feet, and a distinct off-shore current was found between 1,900 and 2,000 feet. More recently (1902), on the west coast of Scotland, Dines, using kites, has noted that the kites would not rise above 1,500 feet on sunny afternoons, when the on-shore breeze was blowing.—*Quar. Jour. Roy. Met. Soc.*

ELECTRICITY DIRECT FROM CARBON.

Lorenz has published a summary of the present state of the problem of converting chemical energy of burning carbon directly into electricity. Slow combustion involved in the electrolytic process such as in an ordinary voltaic cell suffers under three disadvantages, viz.: the slowness of the reaction between carbon and oxygen at ordinary temperatures, the impurity of the carbon, which gives rise to complicated hydrocarbons in solution and the necessity of using the highly-priced conducting forms of carbon instead of ordinary coal. These circumstances lead to the adoption of a gaseous "electrode"

consisting of carbon monoxide, as in the cells of Bucherer and Borchers. In these, however, the currents obtained cannot be proved to result from the further oxidation of the carbon monoxide. Indeed, the existence of carbon monoxide ions has yet to be demonstrated. Another but more indirect way of utilizing the energy of carbon is that suggested by Nernst, in which carbon is used for regenerating other cells, such as a Daniell cell, by the reduction of the zinc sulphate. Another method proposed by Nernst is to heat an accumulator having a negative temperature coefficient until its e.m.f. disappears and then let it cool. Dolezalek has in fact obtained an e.m.f. of 0·6 volt between two lead accumulators having a difference of temperature of 90°. The problem is theoretically soluble, but will require much detail work for its final solution.—*Electrical World.*

Book Notices.

Encyclopedie des Aide-Memoire: Librairie Gauthier-Villars. Paris.

Since our last notice of this useful publication, the under-mentioned volumes of this series have reached us. Each individual member of the series is complete in itself, and treats, more or less elaborately, of some special subject of importance to the engineer. Small 8vo. (Price, 2 fr. 50c. in paper; 3 fr. in cardboard.)

Miron (*François*), Licencié ès sciences physiques, Ingénieur civil.—Gisements minéreaux. Stratigraphie et composition.

Miron (*François*), Licencié ès sciences physiques, Ingénieur civil.—Les gisements miniers. Stratigraphie. Composition.

Morel (*Marie-Auguste*), Ingénieur, ancien Elève de l'École des Ponts et Chaussées, Licencié ès sciences mathématiques et physiques, directeur des usines à ciment Portland de Lumbres.—Les matériaux artificiels.

Colomer. Mise en valeur des gites minéraux.

W.

Report of the Commissioner of Education for the year 1902: Vol. I. 8vo, pp. cxii + 1176. Washington: Government Print. 1903.

The character and scope of the work of the National Bureau of Education can only be properly appreciated by an examination of the imposing volumes giving the results of its activity, which are issued yearly under its direction, and the wide range of topics which are covered.

W.

The Electrolysis of Water: Processess and applications. By Victor Engelhardt, Chief-engineer and Chemist of the Siemens & Halske Company, Ltd., Vienna. Authorized English translation by Joseph H. Richards, M.A., A.C., Ph.D., President of the American Electrochemical Society, etc. (With 90 figures and 15 tables in the text.) 8vo, x + 140 pp. Easton, Pa.: The Chemical Publishing Company. (Price: paper, $1.00; cloth, $1.25.

This work has already been noticed in these pages in the original German. The present translation by Dr. Richards needs no encomium at our hands as to its accuracy. W.

Howe's Hand-book of Parliamentary Usage. Arranged for the instantaneous use of legislative and mass meetings, clubs and professional orders, teachers, students, workingmen and all who desire to conduct themselves "decently and in order" in public assemblies. By Frank William Howe. (12mo, pp. 84.) New York: Hinds & Noble. 1904. (Price, 50 cents.)

The specially useful feature of this hand-book is a revised arrangement of the whole subject-matter of parliamentary law, which should make it quite useful to the presiding officers of public meetings, and especially to those who may be inexperienced. W.

Die für Technik und Praxis wichtigsten Physikalischen Grössen in Systematischer Darstellung. Die algebraische Bezeichnung der Grössen, Physikalische Masssysteme, Nomenklatur der Grössen und Masseinheiten. Von Dr. Olaf Linders, Maschinen- und Electro-Ingenieur. 8vo, pp. 396. (Mit 43 Textfiguren.) Leipzig: Verlag von Jäh & Schunke (Rosstergische Buchhandlung), 1904. (Price, Rm. 10.)

A work of this kind is always welcome to the investigator and student It will be found especially elaborated in connection with the magnetic and electrical constants. W.

The Optical Rotating Power of Organic Substances and Its Practical Applications. By Dr. Hans Landoldt, Professor of Chemistry in the University of Berlin; assisted by Dr. O. Schönnock, P. Linders, F. Schütt, L. Berndt, T. Posner. Second edition. Authorized English translation with additions by Dr. John H. Long, Professor of Chemistry in Northwestern University, Chicago. (Illustrated.) Easton, Pa.: The Chemical Publishing Company, 1902. (Price, $7.50 net.)

The first edition of this standard work appeared in 1879. The present edition brings the subject up to date by the introduction of the work of van 't Hoff and LeBell. The book will be imperatively needed by chemical instructors and specialists in the field which it covers. W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, March 16, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 16, 1904

MR. JOHN BIRKINBINE, President, in the chair.

Present, 184 members and visitors.

Additions to membership since last report, 6.

The Secretary reported that three vacancies existed in the Committee on Science and the Arts, caused by the death of Mr. Luther L. Cheney and the

resignations of Prof. Edgar Marburg and Mr. Clayton W. Pike. These were filled by the election of Mr. Wm. H. Thorne in place of Mr. Cheney; Mr. Richard L. Binder in place of Mr. Pike; and Mr. A. W. Allen in place of Professor Marburg. A letter was received from Mr. George V. Cresson, trustee of the Elliott Cresson Fund, announcing the death of Mr. S. Lloyd Wiegand, senior member of the trustees.

A special committee was appointed, consisting of Mr. H. R. Heyl (representing the Committee on Science and the Arts), Mr. James M. Dodge, (representing the Board of Managers) and Mr. A. E. Outerbridge, Jr. (representing the Institute at large), to report to the next stated meeting of the Institute the name (or names) of a suitable successor to fill the vacancy.

Mr. Julius F. Sachse, of Philadelphia, exhibited and commented on a series of lantern photographs, made from various historic sources, showing views of "Old Philadelphia." The collection, as a whole, is unique, and the exhibition was received with the approbation which the interest and importance of the collection justified.

Mr. C. C. Balderston, of Williams, Brown & Earle, Philadelphia, made some informal remarks on the subject of radium and other radio-active substances. He, likewise, exhibited some specimens of radium salts and several forms of apparatus in the treatment of diseases (cancerous growths and the like). He concluded his remarks by the exhibition of a series of radiographs, which showed in an instructive manner the relative transparency (or opacity) of a variety of substances (metals, glass, paper, rubber, etc.), to the radium rays. A comparison of radiographs of the same subjects, made by the action of the X-rays and radium rays, exhibited interesting differences. Interesting items of the exhibits were radiographs, apparently made from rays emanating from glass, rendered radio-active by having contained some radium salts, and from water rendered radio-active by the immersion therein of a glass tube containing radium salt.

Dr. John B. Shober also exhibited and described some interesting radiographs, showing instructively the comparative penetrating action of radium salts in various media.

The thanks of the meeting were tendered to the several speakers for their interesting contributions.

The meeting was closed by the exhibition of a fire-proof metal window and frame, made by Messrs. David Lipton Sons & Company of Philadelphia. The apparatus was described in detail, and its several novel features illustrated in operation.

Adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

(*Abstract of the proceedings of the stated meeting, held Wednesday, March 2, 1904.*)

PROF. LEWIS M. HAUPT in the chair.

The following reports were considered:

(No. 2164.) *Steam Generator.* John C. Parker, Philadelphia.

This report is reserved for publication in full. The Elliott Cresson Medal is awarded to the inventor. (*Sub-Committee.*—Francis Head, Chairman; Chas. Day, Thos. P. Conard, J. M. Emanuel.)

(No. 2279.) *Electric "Buzz" Fan.* Dr. S. S. Wheeler.

Final action postponed.

(No. 2216.) *The Nernst Lamp.* Nernst Lamp Company, Pittsburg, Pa.

A provisional report, suggesting the continuation of the Sub-Committee until additional data can be collected. (*Sub-Committee.*—Arthur J. Rowland, Chairman.)

W.

Sections.

[*Abstracts of stated meetings.*]

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting*, held Thursday, February 25, 8 P.M. Present, 64 members and visitors. Mr. James Christie called the meeting to order, and requested Mr. Wm. Penn Evans to take the chair.

The paper of the evening was read by Mr. Henrik V. Loss, on "The Manufacture of Hydaulically Forged and Rolled Railway Steel Wheels." The speaker illustrated the subject by the exhibition of a 36-inch wheel made by this process, and by means of numerous lantern photographs showing details of the specially designed machinery employed, the successive steps in the operations of manufacture, the microstructure of the finished product, etc.

An extended discussion ensued. (This subject is referred for publication.)

The thanks of the meeting were extended to the speaker of the evening for his interesting communication.

The Executive Committee announced the appointment of Mr. G. H. Clamer as President of the Section for the year 1904.

D. EPPELSHEIMER, JR.,
Secretary.

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, held Thursday, March 10, 8 P.M. President G. H. Clamer in the chair. Mr. H. A. Kimber, representing the Loomis-Pettibone Fuel Gas Company, of New York, read a paper on "Fuel Gas," illustrating the subject with the aid of a series of lantern photographs. The subject was freely discussed. The meeting passed a vote of thanks to the speaker of the evening, and adjourned.

WM. H. WAHL,
Secretary.